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Information and Data Management Study

Final Report

Phase III -

Data/Technology Survey and Analysis

Preliminary Draft

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Draft Report
Data/Technology Survey and Analysis Phase

Information and Data Management Study

for the
Bureau of Land Management
United States Department of the Interior

Contract Number 08-550-CT4-14

Prepared by the
Strategic Plan Study Team
BLM-Denver
and
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1.0 INTRODUCTION

This is the Phase III "Data/Technology Survey and Analysis", report for the Bureau of Land Management "Information and Data Management Study". It is the third of five reports which, together with the "BLM Strategic Information Plan", are the final products of this study.

The purpose of this study is to develop a strategic plan to apply appropriate Automatic Data Processing and Remote Sensing system technologies to the needs of the Bureau of Land Management on an evolutionary basis while at the same time solving the problems associated with data/information and process deficiencies that may exist within BLM.

The study is being conducted in five phases:

Phase I -- Planning and Coordination

Phase II -- Site Survey and Analysis

Phase III - Data/Technology Survey and Analysis

Phase IV -- Systems Recommendations

Phase V -- Plan Formulation

The objectives of Phase III were to survey and analyze the state-of-the-art in remote sensing and automatic data processing technologies.

The requirement to analyze ADP technology (Task 1 AB-9) to be satisfied by the provision of independent surveys to BLM in a separate submission. This document will address only remote sensing/image processing technology.

The remainder of this report is organized along the same lines as the IBM Technical Proposal.

Task 1AB-1/2. "Review of Earth Resource Survey Program" describes how existing remote sensing material is collected and used for further analysis relating to the formulation of the strategic plan. "Classify and Catalog Earth Resource Mission Parameters" states how different platforms are categorized.

Task 1AB-3. "Determine Maximum Remote Sensing Data Input to BLM by ERS Program" correlates the ERS Programs that provide repetitive coverage and the BLM lands overflown.

Task 1AB-4. "Estimate Actual ERS Data Available to BLM" provides gross estimates of seasonal cloud cover by region.

Task 1AB-5. "Identify Mission Passes per District" delineates the particular ground tracks that cover less than the area of responsibility of a BLM District Office.

Task 1AB-6. "Determine Potential ERS Data Input by BLM Activity" describes how remote-sensed data may be applied to BLM needs.

Task 1AB-7/8. "Survey Image Processing Technology and Systems" associates the state-of-the-art ground image technologies to BLM needs. "Classify and Catalog Image Processing Systems" analyzes image processing equipment and systems by functional common denominators. Several development recommendations regarding BLM image processing capabilities are set forth.

TASK 1AB-1/2: Review of Earth Resource Survey Programs

1. EARTH RESOURCE SURVEY PROGRAM OVERVIEW

"We are beginning to understand the fundamental relationship between the earth's resources, including our environment, and our modern civilization. For some time, there has been concern with the rate of depletion of certain resources, such as oil and timber reserves and other scarce minerals. Recently, our whole society has come to realize that man must concern himself with much more than a few scarce minerals--we must also protect our air and water, our food supplies, our wilderness with its bird, fish, and animal life, in short, all the resources of our world. But conservation is not the whole problem, for our society requires food, water, minerals, power and land in order to maintain our constantly increasing standard of living and expanding population. Our real environmental problem is one of balancing resource comsumption and conservation. In simpler times that balance was either ignored or resource decisions were made intuitively. Now, there is ample evidence of the complexity of maintaining a rational ecological balance. The effect of insecticides on bird population and the mercury contamination of tuna fish are striking examples of the complex interrelationship between man's activities and nature. Today, there is only limited, reliable information on most of the earth's resources. To manage our environment rationally, we need improved information that quantifies our resources and their rate of change, as well as how both human and natural processes cause these changes. Although some environmental problems are localized, many are widespread and some are global. Gathering and analyzing data on a broad national and international scale must largely be a governmental task--but the use of such information to preserve our environment is the privilege and the responsibility of every element of society, public and private, individual and institutional.

The Earth Resources Survey Program (ERSP) is an experimental effort to provide information to solve problems and to improve national management of our resources and our environment. The program is founded on remote sensing techniques to obtain facts about the earth, advanced communications systems to collect these facts, computers to store and arrange them, and scientists of many disciplines to resolve the data into understandable, usable information for decision makers who are concerned with the management of our world's resources.

Remote sensing, the heart of the system, has been a tool for limited exploration of the earth for more than a century, primarily in the form of surface and aerial photography. In recent times, refined sensing techniques have been developed. New and improved sensors are now carried on high altitude, longrange aircraft to enhance programs for exploration,

mapping, inventorying and warning. Our space capability adds new dimensions to resources surveying by making it feasible to observe large areas of the earth repeatedly, over a period of years. This combined capability for spacecraft and air-craft observation offers the possibility of conducting both large scale and detailed surveys to:

-- learn about our earth by conducting large scale, repetitive inventories of its visible resources.

-- measure and understand natural and man-made changes in our environment.

-- develop information which will assist decision makers at all levels to manage rationally and beneficially our resources and our environment."[1]

[1]Report of the Interagency Ad Hoc Study Group on the Earth Resource Survey Program (Ander's Report)

1.1 PROGRAM GOALS

The overall goals of the Federal Earth Resources Survey Program are: (1) to provide a data acquisition capability to collect remotely sensed information on the conditions of the land, the oceans, and the atmosphere; (2) to provide a data handling and processing capability for translating the data into an analyzable form and insure effective distribution; (3) to provide interpretative techniques and methods of analysis for converting data into earth resources information; and (4) to provide the means for applications analysis and technological transfer permitting the effective application of information to earth resources management. Section 3 identifies the specific goals and objectives of the Federal Earth Resources Program.

NASA's goals and objectives comprise a subset of the federal programs, aimed primarily at the development and transfer of remote sensing technology to operating agencies. Three primary goals have been established: (1) develop the capability for remote sensing of the Earth from aircraft and spacecraft; (2) develop experimental and operational applications of ERS technology to meet user requirements; (3) develop methods of handling large quantities of remotely sensed data, including the transmission, reduction, processing, storage and retrieval, and dissemination.

[2]Annual Federal Report on the Earth Resource Survey Program (Prepared by the ICCERSP)

1.2 PARTICIPANTS AND MANAGEMENT RELATIONSHIPS

The Federal Earth Resources Survey Program includes NASA; the Environmental Protection Agency; the U.S. Army Crops of Engineers; and the Departments of Agriculture, Commerce, Defense, Interior, and State. The interagency interest was formally recognized in early 1972 by the creation of the Federal Earth Resources Survey Program under the guidance of an Interagency Coordinating Committee (ICCERSP).

The ICCERSP is the primary executive branch mechanism for coordinating and integrating Federal Earth Resources Survey plans, policies, and programs. The charter issued by the Office of Management and Budget establishing the Committee defines its responsibilities and authority as: (1) coordination and integration of the Federal Earth Resources Survey Program; (2) coordination with related agency programs; (3) coordination outside the Federal government; and (4) preparation of an annual federal report and plan.

1.3 MAJOR PROGRAM ELEMENTS

For the purposes of this Summary, the Program is divided into elements by functional/technical areas. The major elements are: (1) Research and Technology Development, (2) Flight Projects, (3) Exploratory Investigations, and (4) Application Systems Verifications Tests (ASVT).

1.3.1 Research and Technology Development

Activities comprise those basic research and development efforts which maintain the state-of-the-art technology base necessary for program capabilities to progress. The technology base includes sensors, data handling and processing systems, and interpretation/classification techniques.

Sensors are further subcategorized into camera and video systems, scanners and spectrometers, and passive and active microwave systems. They include all program sensing instruments aboard spacecraft, aircraft, and surface platforms.

Data handling and Processing includes the photographic facilities which process film data, the electronic data processing systems which convert raw data into computer compatible tapes, and the data storage, transmission, retrieval, and distribution facilities.

Interpretation/Classification Techniques Development encompasses those activities which seek to improve methodologies and techniques used to convert data into useful information. Various techniques, for example standard photointerpretation, automatic pattern recognition and classification, image enhancement, and sensor/signature analysis, are included. Other activities are those devoted toward developing and improving models and sampling designs.

1.3.2 Flight Projects

Consist of the instrument platforms, spacecraft and aircraft, and the associated subsystems.

Current R&D spacecraft include the Earth Resources Technology Satellite and the Earth Resources Experiments Package aboard Skylab. Potential future platforms include the Earth Observation Satellite (EOS), the Synchronous Earth Observatory Satellite (SEOS), and various Earth Resources payloads for the Shuttle. Each of the spacecraft platforms has a unique complement of remote sensors and onboard data systems. The spaceborne data inputs to the more advanced models relating remote sensing to resource survey applications.

The NASA program includes a number of aircraft: light, low altitude, regional aircraft and medium and high altitude aircraft. The aircraft serve two major functions within the Program: (1) test beds for sensor development and (2) data acquisition for applications and techniques development investigations.

1.3.3 The NASA Program is directed toward the development and demonstration of applications of remote sensing technology which have economic and social benefits. These applications are categorized into discipline areas; i.e., agriculture, range, and forestry; land use survey and mapping; mineral resources, geologic structure, and land form surveys; water resources; marine resources and ocean surveys; and environment. Two types of applications activities are conducted within the program.

Exploratory Investigations are conducted within all applications discipline areas of the program. They result in evaluations of data techniques, special case demonstrations, signature determinations, methods to utilize instrumentation, useful models, and definition of promising applications. From these exploratory results, ASVT's are defined to demonstrate the capability to satisfy one or more of the program objectives.

An Applications Systems Verification Test is an integrated test of the total technical capability required to accomplish a specific application objective. It accomplishes a thorough evaluation of the capability, measures and quantifies the reliability and accuracy of such a capability, and provides us an output all of the information necessary for a potential

user to make effective decisions concerning implementation of the technology in an operational applications system. Mandatory products from an Applications Systems Verification Test are a documented methodology suitable for wide-spread use, a complete evaluation and measurement of accuracy and reliability, and complete cost benefit relationship study.

Two areas of effort are required. The first and most difficult is to develop the Operational Methodology and the second is to Demonstrate its capability. ASVT's are designed to utilize data acquired from flight projects. Operational methodology includes development of the application system. The demonstration culminates in documented methodology sufficient for the user organization to make go/no-go decisions relative to implementing the application system.

Advanced studies that define systems, e.g., spacecraft, sensors, and data handling and processing, and methodology useful in the making of management decisions concerning near and long term resource expenditures may be conducted within any program element.

1.4 PROGRAM SCHEDULE SUMMARY

Figure 1 shows the current schedule of the major project of the ERS program. It should be noted that ERTS-C, EOS, and SEOS schedules are preliminary plans only; these projects have not yet been approved.

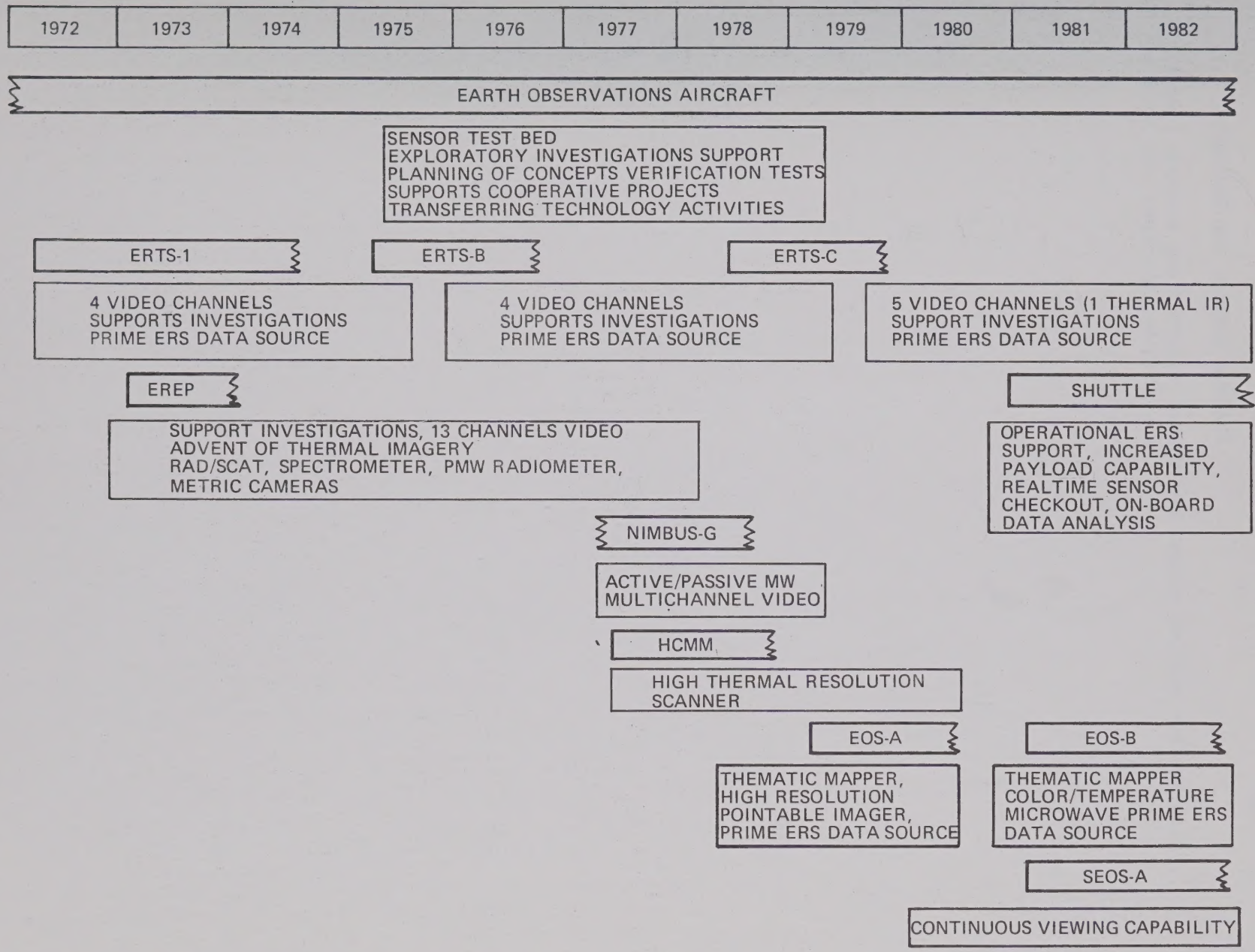

Figure 1. ERS Flight Projects

1.5 SENSORS AND SYSTEMS SUMMARY

Table 1 depicts the currents sensor and remote sensing systems plans, status, and required research.

Table 1. SENSORS AND SYSTEMS SUMMARY

TECHNOLOGY AREA	CURRENT STATUS	PLANNED OR UNDERWAY	NEEDED	PRIORITY
CAMERA/VIDEO SYSTEMS				
o IMPROVED SPACIAL/SPECTRAL PERFORMANCE VIDEO SYSTEMS o IMPROVED SPACIAL/SPECTRAL PERFORMANCE CAMERA SYSTEMS	o RBV o S-190A o S-190B o AMPS	o GSFC OCEAN SCANNING SPECTROPHOTOMETER o FRAUNHOFER LINE DISCRIMINATOR o RBV DEVELOPMENT (4000 LINE) o GSFC COLOR ENCODING o SIS o LARC LIDAR o MOCS o S-190A, S-190B o AMPS o COLOR CALIBRATION (LARC)	o METRIC QUALITY SPACE CAMERA o HIGH RESOLUTION SPACE CAMERA	LP
SCANNERS/SPECTROMETERS				
o HIGH SPECTRAL, SPACIAL PERFORMANCE SCANNERS o HIGH PERFORMANCE OPTICAL SYSTEMS o IMPROVED SCAN MECHANISMS o IMPROVED DETECTOR COOLING SYSTEM	o ERTS MSS o S-192 o MSDS o S-191 o OAO o ATM o NIMBUS	o HRPI o EOS THEMATIC MAPPER o GSFC SCANNING SPECTRORADIOMETER BREADBOARD o HIGH RESOLUTION SHUTTLE SCANNER o EOS SEA SURFACE TEMP RAD o SOLID STATE DETECTOR TECHNOLOGY (GSFC) o 1.5 TO 3.0 METER OPTICAL SYSTEMS DEVELOPMENT o ERTS-B RADIATIVE COOLER o EOS COOLER	o ACTIVE SCANNER DEVELOPMENT o IMPROVED DETECTORS AND DETECTOR DETECTOR ARRAY TECHNOLOGY o ACCURATE/STABLE ON-BOARD CALIBRATION SYSTEMS o OPTICAL MATERIAL, OPTICAL COATINGS, COOLED OPTICS, IMPROVED SPECTROMETER DESIGNS o LONG LIFE COOLING (ACTIVE OR PASSIVE) o DEFINE SPATIAL/SPECTRAL IMAGE	HP HP HP P HP

HP - HIGH PRIORITY P - PRIORITY LP - LOW PRIORITY

Table 1. SENSORS AND SYSTEMS SUMMARY (Continued)

TECHNOLOGY AREA	CURRENT STATUS	PLANNED OR UNDERWAY	NEEDED	PRIORITY
PASSIVE M/W SYSTEMS				
o IMPROVED SPACIAL RESOLUTION, MULTIFREQUENCY PASSIVE M/W SYSTEMS	o MFMR o PMIS o NIMBUS ESMR o S-193 o S-194 o AAFE S-BAND	o DEFINITION OF SHUTTLE IMAGING M/W SYSTEM	o DEVELOP LOW LOSS, HIGH BEAM EFFICIENCY, BROADBAND ANTENNAS o EVALUATE ELECTRICAL VS MECHANICAL SCAN ANTENNAS o HIGH DETECTIVITY, LOW LOSS, FERRITE DEVICES, SWITCHES, AND ISOLATORS o LOW NOISE (LESS THAN 5DB) BROADBAND MIXER - IF PREAMPLIFIERS	P P P P
ACTIVE M/W SYSTEMS				
o DEVELOP MULTIFREQUENCY, MULTIPOLARIZATION RADARS FOR EARTH RESOURCES	o AAFE RADSCAT o ERIM X/L BAND o S-193	o U OF MICHIGAN S/L BAND o RADAR WORKSHOP o S-193	o DETERMINE EARTH RESOURCES INFORMATION o CONDUCT A/C AND GROUND BASED RADAR SIGNATURE STUDIES o EVALUATE ON-BOARD DIGITAL RECORDING	HP HP HP
SUPPORTING SYSTEM TECHNOLOGY		o SYNTHETIC APERTURE RADAR FOR SHUTTLE		
o IMPROVED GEOMETRIC ACCURACY	o ERTS	o GSFC PADS (EOS)	o ON-BOARD DATA COMPRESSION TECHNIQUES	P
o IMPROVED DATA THROUGHPUT	o EREP	o HYBRID PROCESSORS	o ON-BOARD DATA SCREENING	LP
o REDUCED DATA COST		o DATA RELAY SATELLITES	o GENERAL SPACE RELAY TECHNOLOGY OF IN-SITU MEASUREMENTS	LP
o IN-SITU MEASUREMENTS		o SMALL GROUND RECEIVERS	o 200 MBPS RECORDER (SPACECRAFT AND GROUND FACILITY)	HP
o IMPROVED DATA RECORDING		o GSFC ON-BOARD PROCESSING TECHNIQUES		
		o 5 YEAR LIFE TAPE RECORDER		
		o ERTS DCS		

HP - HIGH PRIORITY P - PRIORITY LP - LOW PRIORITY

2. AIRCRAFT PROJECTS

2.1 DESCRIPTION AND OBJECTIVES

The NASA Earth Resources Aircraft Program, along with the Advanced Applications Flight Experiments (AAFE) Program, has supported the development of remote sensing techniques which are used in the measurement of earth surface characteristics from satellites. Aircraft have made possible the use of large sensor payloads, permitting a wide latitude in sensor planning.

Primary emphasis during FY 1973 was in support of the ERTS and DREP investigations by providing underflights and prelaunch experience. In FY 1974 and beyond, the Aircraft Program will support EREP, follow-on ERTS missions, and will continue research in remote sensing techniques. Also, the Aircraft in future years will be used as test beds for other earth observations sensors provided by other NASA Centers.

The major objectives of the program are:

- To develop measurements techniques using remote sensors
- To acquire data for developing analysis and interpretation methods
- To provide Aircraft acquired data for correlation to data acquired by Spacecraft

2.2 NASA JSC AIRCRAFT Applications

NASA JSC currently flies 5 aircraft:

NP3A (ERS #1)

Provides medium-altitude (to 25,000 feet) platform primarily utilized for oceanographic applications. Sensor complement includes metric and multiband cameras; IR sensors, and active and passive microwave instrumentation.

NC130B (ERS #2)

Provides medium-altitude (to 30,000 feet) platform primarily for multidiscipline research activities with the 24-channel multispectral scanner. Sensor complement includes metric and multiband cameras and multispectral scanner.

WB57F (ERS #3 and #6)

Provides high-altitude (to 65,000 feet) platform for multidicsipline research activities from above 92 percent of the earth's atmosphere. Sensor complement includes metric and multiband cameras and IR sensors; a visible spectral radiometer is planned for ERS #3.

Bell 476-3B (HELO)

Provides low-altitude platform for ground truth activities associated with the Houston Area Test Site. Sensor complement currently includes an IR spectrometer, similar to EREP S191.

2.3 AIRCRAFT SENSORS

Table 2 depicts the proposed primary sensor complement-CY 1976.

ISOR	ERS #1	ERS #2	ERS #3	ERS #6	HELO
IERA SYSTEMS (0.4-0.92 MICROMETERS)					
NEW ZEISS METRIC	X	X	X	X	
AMPS	X	X		X	
HIGH RESOULUTION (CAI)			X		
ZEISS L2"			X		
HASSELBLAD			X		
ETC		X			
IBLE-INFRARED SYSTEMS					
REPLACEMENT THERMAL SCANNER (8.0-14 MICROMETERS)			X	X	
MSS (0.34-13.0 MICROMETERS)		X			
CAMS			X		
ETC				X	
SIS (0.4-0.85 MICROMETERS)			X		
LASER PROFILER (0.63 MICROMETERS)	X				
RADIATION THERMOMETER (PRT-5) (8-14 MICROMETERS)	X	X			
MMS	X				
FIELD SPECTROMETER SYSTEM				X	
ROWAVE SYSTEMS					
SINGLE-POLARIZED SCATTEROMETER (13.3 GHz)	x				
MFMR (L, X, K, KA BANDS)	X				
PMIS (10.69 GHz)	x				
L-BAND RADIOMETER (ERL)				X	
ROWAVE SYSTEMS					
ADVANCED SLAR (UNDEFINED)	X				
PORT SYSTEMS					
TAPE RECORDER	X	X	X	X	X
ANNOTATION SYSTEM	X	X	X	X	
INERTIAL NAVIGATIONAL SYSTEM	X	X	X	X	
DUAL DME	X	X	X	X	
RADAR ALTIMETER	X	X	X	X	X
OPTICAL VIEWFINDER			X	X	

Table 2. PROPOSED PRIMARY SENSOR COMPLEMENT - CY 1976

3. SATELLITE PROGRAMS

3.1 ERTS-1

ERTS-1 is the first spacecraft system designed specifically for earth resources surveys. It has operated continuously since launch in July 1972 providing experimental data for over 350 domestic and foreign investigations in all discipline areas. The experience gained with this prototype of future space systems will prove invaluable. The results of the investigations have made the experiment an unqualified success. Several applications in each discipline area have been proven feasible and identified as potential candidates for Application System Verification Tests (ASVT's). The orbital parameters, sensor spatial quality, giving serious consideration to acquiring a slightly modified ERTS for the first operational system.

Although the ERTS is a U.S. facility, it is acquiring data over many foreign countries for over 100 foreign investigators who are conducting evaluations of the data for resources applications. These investigations are sponsored and supported by their respective countries with the U.S. providing the data. The data acquired is in the public domain and obtainable for the cost of reproduction only at the U.S. Department of Interior's Earth Resources Observation System data center at Sioux Falls, South Dakota.

The experience gained at the NASA Data Processing Facility (NDPF) at Goddard Space Flight Center, where all the telemetered data are processed prior to simultaneous release to the investigators and the EROS data center, has answered many of the questions concerning the handling and processing of a continuous flow of large quantities of data.

With all of its successes and the knowledge gained from ERTS, it is still the "Model T" of earth resources space remote sensing systems. Many improvements and advances are necessary to satisfactorily meet application requirements.

The experimental investigations of ERTS-1 have met their objectives and follow-on efforts will emphasize the demonstration of the ERTS system capability to perform quasi-operational applications.

The Earth Resources Technology Satellite payload includes: a Return Beam Vidicon (RBV) camera subsystem, a Multispectral Scanner Subsystem (MSS) and a Data Collection System (DCS). The RBV and MSS furnish independent views of the earth beneath the Observatory, while the DCS relays local environmental information from remote platforms to the ground stations for processing and delivery to users.

3.1.1 Return Beam Vidicon Camera

The Return Beam Vidicon (RBV) camera subsystem contains three individual cameras that operate in different nominal spectral bands. Each camera contains an optical lens, a shutter, the RBV sensor, a thermoelectric cooler, deflection and focus coils, erase lamps and the sensor electronics. The cameras are similar except for the spectral filters contained in the lens assemblies to provide separate spectral viewing regions. The sensor electronics contain the logic circuits to program and coordinate the operation of the three cameras as a complete integrated system and provide the interface with the other spacecraft subsystems. Table 3 shows the major camera parameters and their expected performance. A malfunction in the switching subsystem has prohibited the use of the RBV on ERTS-1, since a few days after launch.

Item	Camera 1	Camera 2	Camera 3
Nominal Spectral Band (Micrometers)	.475-.575 Blue-Green	.580-.680 Green-Yellow	.698-.830 Red-IR
Abbreviated Band Reference	Blue	Yellow	Red
Edge Resolution (% of center)	80%	80%	80%
Video Bandwidth (MHz) without Aperture Correction	3.2(-20dB)	3.2(-20dB)	3.2(-20dB)
Signal-To-Noise Ratio (at 100% high-light) Aperture Correction Out	33dB	33dB	31dB
Horizontal Scan Rate (lines/second)	1250	1250	1250
Number of Scan Lines (active video)	4125	4125	4125
Readout Time (seconds of active video)	3.5*	3.5*	3.5*
Readout Sequence	3	2	1
Focal Length of Lens (mm)	125.865	125.824	125.979
Exposure Set Time (msec)			
No. 1	4.0	4.8	6.4
No. 2	5.6	6.4	7.2
No. 3	8.0	8.8	8.8
No. 4	12.0	12.0	12.0
No. 5	16.0	16.0	16.0

*Readout time includes 3.3 seconds ground video, and 0.2 second sync and time code information.

Table 3 RBV Camera Parameters

3.1.2 Multispectral Scanner Subsystem

The Multispectral Scanner Subsystem (MSS) gathers data by imaging the surface of the earth in several spectral bands simultaneously through the same optical system. The MSS for ERTS A is a 4-band scanner operating in the solar-reflected spectral band region from 0.5 to 1.1 micrometer wavelength. It scans crosstrack swaths of 185 kilometers (100 nm) width, imaging six scan lines across in each of the four spectral bands simultaneously. The object plane is scanned by means of an oscillating flat mirror between the scene and the double-reflector, telescope type of optical chain. The 11.56 degree cross-track field of view is scanned as the mirror oscillates $\pm$2.89 degrees about its nominal position as shown in Figure 2-1.

The instantaneous field of view of each detector subtends an earth-area square of 79 meters on a side from the nominal orbital altitude. Field stops are formed for each line imaged during a scan, and for each spectral band, by the square input end of an optical fiber. Six of these fibers in each of four bands are arranged in a 4 by 6 matrix in the focused area of the telescope.

Light impinging on each glass fiber is conducted to an individual detector through an optical filter, unique to the spectral band served. An image of a line across the swath is swept across the fiber each time the mirror scans, causing a video signal to be produced at the scanner electronics output for each of 24 channels. These signals are then sampled, digitized and formatted into a serial digital data stream by a multiplexer. The sampling interval is 9.95 sec, corresponding to a cross track motion of the instantaneous field of view of 56 meters.

The along-track scan is produced by the orbital motion of the spacecraft. The nominal orbital velocity causes an along-track motion of the sub-satellite point of 6.47 km/sec neglecting spacecraft perturbation and earth rotation effects. By oscillating the mirror at a rate of 13.62 Hz, the subsatellite point will have moved 474 meters along track during the 73.42 millisecond active scan and retrace cycle. The width of the along-track field of view of six detectors is also 474 meters. Thus, complete coverage of the total 185 kilometer wide swath is obtained. The line scanned by the first detector in one cycle of the active mirror scan lies adjacent to the line scanned by the sixth detector of the previous mirror scan. Figure 2-2 shows this composite scan pattern.

The MSS subsystem is used on two missions; for the ERTS A and B missions four selected spectral bands are:

Band 1	0.5 to 0.6 micrometers
Band 2	0.6 to 0.7 micrometers
Band 3	0.7 to 0.8 micrometers
Band 4	0.8 to 1.1 micrometers

Bands 1 through 3 use photomultiplier tubes as detectors; Band 4 uses silicon photodiodes.

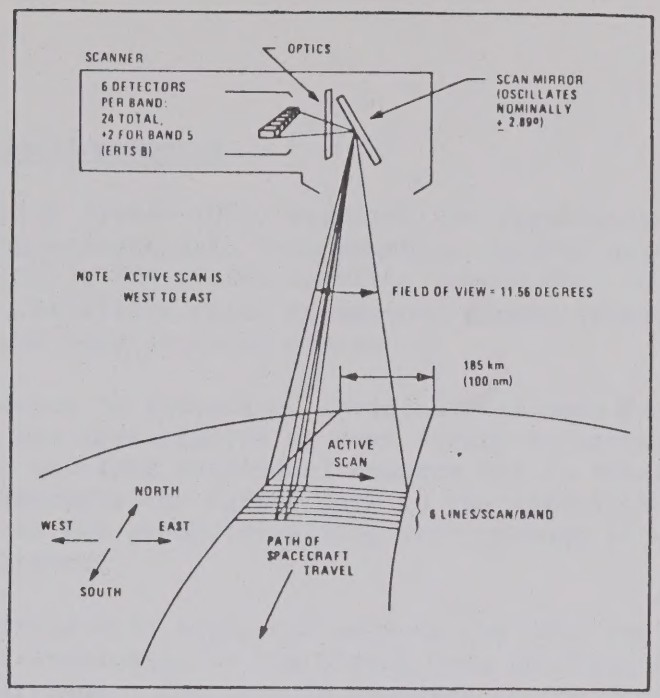

Figure 2-1. MSS Scanning Arrangement

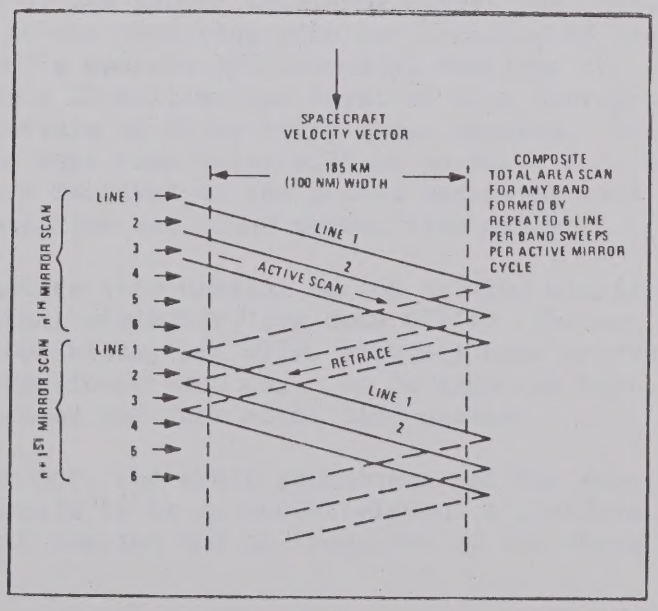

Figure 2-2. Ground Scan Pattern
for a Single MSS Detector

3.1.3 Data Collection System

The Data Collection System (DCS) provides the capability to collect, transmit, and disseminate data from remotely located earthbased sensors. As shown in Figure 3, the system involves remote Data Collection Platforms (DCP), satellite relay equipment, ground receiving site equipment, and a ground data handling system.

The DCP is connected to individual environmental sensors which are selected and provided by the investigator or user agency to satisfy his own particular needs. Up to eight individual sensors may be connected to a single DCP. The DCP transmits the sensor data to the satellite which in turn relays the data to the ground receiving site through an on-board receiver/transmitter.

The ground receiving site equipment accepts the data and decodes and formats it for transmission to the Ground Data Handling System (GDHS) at Greenbelt, Maryland. The data is received in the Operations Control Center (CC) where it is reformatted and written on magnetic tape and then either transmitted direct to the user or passed on to the NASA Data Processing Facility (NDPF) for further processing and cataloging required for dissemination to the user agencies.

The satellite is at an altitude of approximately 500 nautical miles. The transmitting antenna of the DCP subtends an angle of ± 85 degrees from the vertical. When the satellite is in mutual view of a transmitting DCP and one or more of the ground receiving sites, the message from the DCP is relayed to the receiving site and transmitted over land lines to the OCC. The DCP's operate continuously, sampling the sensors periodically and transmitting a 38-millisecond burst of data containing all sensor channels at intervals of about every three minutes. Note that the satellite acts as a simple real time relay with no on-board data storage. The DCP transmissions are received at the ground receiving site immediately except for propagation and fixed system time delays.

The orbit parameters (the orbital period is $\sim$103 minutes) allow for up to 9 minutes of mutual visibility for some DCP's. The use of three receiving sites, Alaska, Goldstone, and NTTF, provides nine active passes over the North American Continent each day. It is expected that there will be five daylight passes and four night time passes.

For a particular DCP, the orbit parameters and the receiving site locations cause the spacecraft to be in mutual view of a platform located almost anywhere in North America and at least one of the three ground receiving

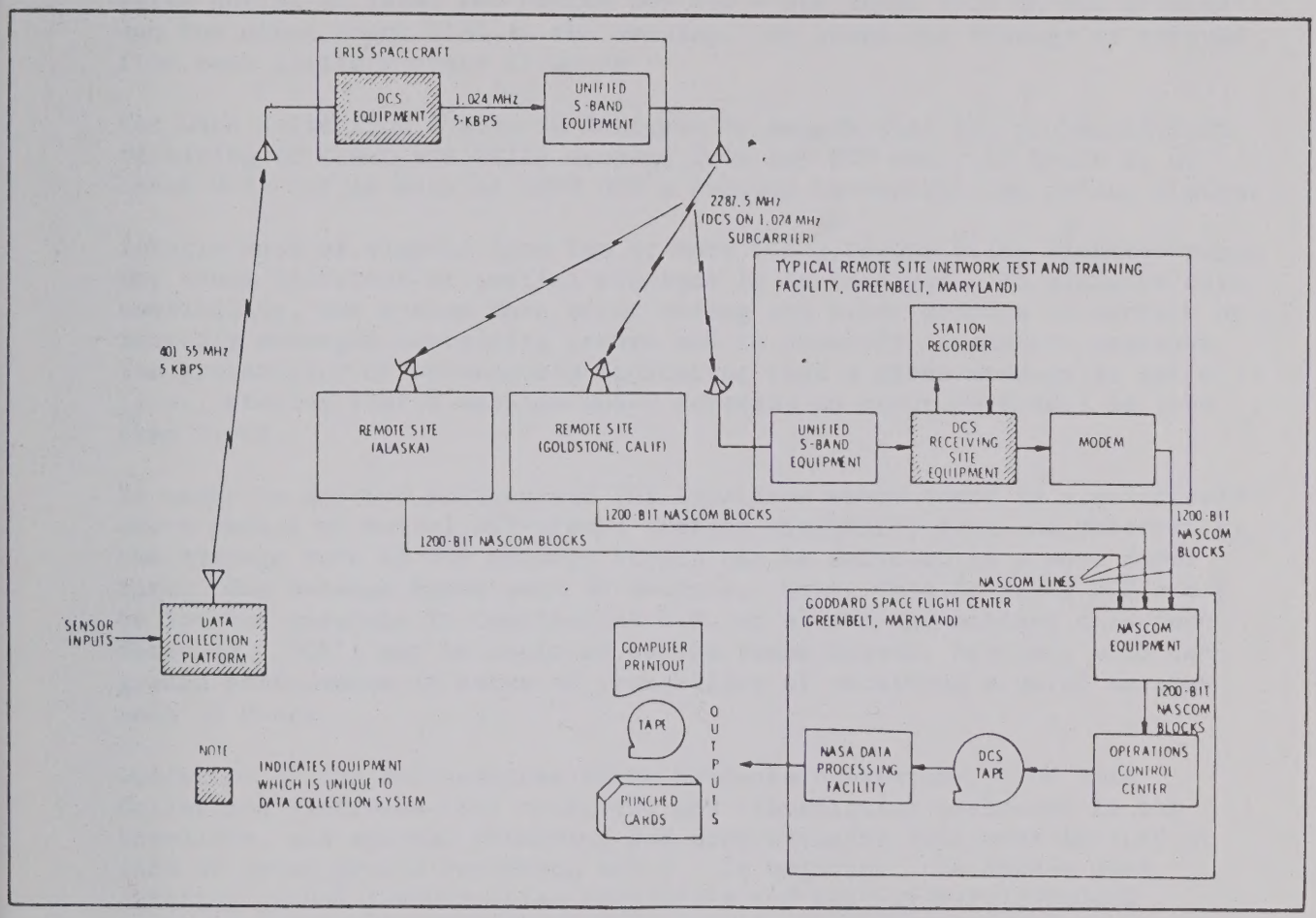

Figure 3. Data Collection System Block Diagram

sites during at least two orbits per day - one about 9:30 in the morning and the other about 9:30 in the evening. At least one message is relayed from each platform every 12 hours.

The Data Collection System is designed to assure that the probability of receiving at least one valid message from any DCP every 12 hours is at least 0.95 for as many as 1000 DCP's located throughout the United States.

Interference of signals from two or more DCP's transmitting simultaneously may cause incorrect or partial messages to be received. To minimize this possibility, the system uses error coding and other schemes to correct or identify messages containing errors and to identify incomplete messages. The probability of erroneously indicating that a given message is valid (i.e., stating that a message which contains an error does not) is less than 0.001.

In order to improve performance for locations where there is a relatively short period of mutual DCP-ground station visibility from the Observatory, the average rate of DCP message bursts can be switched to a more rapid rate: One message burst each 90 seconds. Using this feature, DCP's may be located anywhere in Continental U.S. or Alaska and achieve this performance. DCP's may be deployed beyond these bounds, however, with degraded performance in terms of probability of receiving a valid message each 12 hours.

Operation of the DCS requires three hardware subsystems - the Data Collection Platforms, the receiving and transmitting equipment in the satellite, and special receiving and preprocessing equipment located at each of three ground receiving sites. In addition, the system uses existing ground communication facilities and the hardware/software capabilities of the OCC and NDPF at Goddard.

3.2 ERTS-B

ERTS-B will be identical to the ERTS-1 satellite in both orbit and payload. Launch is currently scheduled for February 1975.

NASA is allowing users to set up their own ground station and acquire data from the satellite directly. Currently, Brazil, Canada, and Italy are committed to building ground stations.

3.3 ERTS-C

The objectives of ERTS-C are: to continue the repetitive data acquisition mission of ERTS-1 and B; to design, develop, and incorporate a 5th band (thermal IR) into the ERTS-1 design MSS: and to conduct investigations in the ERS disciplines with emphasis on exploration of the usefulness of thermal IR imagery as a complement to multiband visible and near IR data.

The orbit and coverage for ERTS-C will be very similar to ERTS-1. Launch is currently planned for mid 1978.

3.4 SKYLAB EARTH RESOURCES EXPERIMENT PACKAGE (EREP)

The Skylab with the EREP was launched on May 25, 1973, into a circular orbit at an altitude of 435 km and 50-degree inclination. The EREP sensor complement consists of:

S190A - Multispectral Photographic Facility
S190B - Earth Terrain Camera
S191 - Infrared Spectrometer
S192 - Multispectral Scanner (13 bands)
S193 - Microwave Radiometer/Scatterometer/Altimeter
S194 - L-Band Radiometer

The spectrometer is boresighted with a crew-operated view finder and tracker, so that sites as small as 440 meters in diameter can be tracked. The ERTS and EREP scanner include similar bands with approximately the same spatial resolution, but the EREP scanner has improved spectral resolution. The EREP microwave sensors are advanced instruments and will provide some of the first orbital measurements at these frequencies. The ERAP aircraft used to underfly ERTS was also used with Skylab. The Johnson Space Center has responsibility to process and distribute the film and tape recorded from EREP.

3.5 NIMBUS-G

Nimbus-G is a multidisciplinary satellite serving the application areas of pollution, oceanography, and weather and climate. These are three interrelated disciplines and the instruments are generally applicable to multiple disciplines. For example, a multichannel microwave radiometer is applicable to oceanography and meteorology, and a total ozone mapping sensor applies to both atmospheric pollution and weather and climate.

The weather and climate role for Nimbus-G is to obtain data about large scale atmospheric dynamics needed to support pollution and oceanographic investigations and to improve long range weather forecasting and our knowledge of processes affecting climatic change. The measurement of meteorological parameters over a time scale ranging from 12 hours to months or more is applicable to the monitoring and transport of pollutants as well as to increasing our knowledge of the structure, dynamics, and radiative and other energy exchange processes in the atmosphere and oceans. The ability to measure auxiliary parameters such as soil moisture, snow and ice cover, precipitation, and ozone and to more accurately measure sea surface temperature is needed for improved forecasts.

The Nimbus-G payload consists of the following instruments:

- Scanning Multichannel Microwave Radiometer (SMMR) - Measures radiances in four spectral bands with eight channels (because of dual polarization) in the wavelength region 0.8 to 2.8 cm to extract information on sea surface roughness and winds, cloud liquid water content, precipitation (mean droplet size), soil moisture, snow cover, and sea ice maps.

- Stratospheric and Mesopheric Sounder (SAMS) - Operates in a limb-scanning mode and employs pressure-modulated gas cells to obtain profiles of temperature and trace constituents in the region 15 to 100 km.

- Lower Atmosphere Composition and Termperature Experiment (LACATE) - Obtains in a limb-scanning mode profiles of temperature and trace constituents in the region 15 to 70 km.

- Solar- Backscattered Ultraviolet/Total Ozone Mapper System (SBUV/TOMS) - Measures direct and backscattered solar ultraviolet to extract information on variations of solar irradiance, vertical distribution of ozone, and total ozone on a global basis.

- Earth Radiation Budget (ERB) - Measures short and long wave upwelling radiances and fluxes and direct solar irradiance to extract information on the solar "constant," earth albedo, emitted long wave radiation, and the anisotropy of the outgoing radiation. This will continue the efforts to begin on Nimbus-F to measure the variability during the solar cycle.

- Coastal Zone Color Scanner (CZCS) - Measures reflected solar radiances in six spectral bands between 0.443 and 0.950 μm and emitted terres-

trial energy in the region 10.5 to 12.5 μm to extract information on chlorophyll concentrations in the oceans, sediment distribution, gelbstoffe (yellow substance) concentration as a salinity indicator, and temperature of coastal waters and ocean currents with an instantaneous field of view (IFOV) of 800 meters or less.

- Stratospheric Aerosol Measurements (SAM-II) - Measures the extinction of solar radiation at three wavelengths between 0.37 and 1.0 μm at spacecraft sunrise and sunset (viewing the solar disk through the limb of the atmosphere) to infer stratospheric aerosol properties.

3.6 EARTH OBSERVATORY SATELLITE (EOS)

The objectives of the EOS Program are to: develop advanced space-borne sensors; develop advanced spacecraft systems and subsystems; develop more efficient information and distribution systems; and permit the operational use of any hardware of other system components with little or no redevelopment.

Present and future effort is involved in establishing the mission rationale for each proposed mission and in overall engineering definition. Preliminary design and trade-off studies of the sensors are being accomplished and the most cost effective way of flying these instruments must be prepared, along with a firm budget.

Typical instruments being planned for EOS include:

a. Thematic Mapper - The EOSMRG, in their report of November 1971, recommended as the primary instrument a moderate resolution multispectral scanner with an instantaneous field of view (IFOV) no greater than 50 meters. A candidate instrument was under study at that time with an IFOV of 66 meters; subsequent studies indicate an IFOV of 30 meters at 914 -km altitude to be feasible.

b. High Resolution Pointable Imager (HRPI) - The HRPI was originally recommended by the EOSMRG as a high-resolution adjunct to a medium-resolution Thematic Mapper; its role was further developed as an experimental tool for determining the efficiency of long term, high resolution sampled data obtained on a regular programmed basis which could reduce the dependence on aircraft data. In addition to its normal use in this mode, the HRPI can be used for ad-hoc temporary purposes such as flood or hurricane damage assessment.

3.7 SYNCHRONOUS EARTH OBSERVATORY SATELLITE (SEOS)

The purpose of SEOS is to satisfy a number of potential user requirements that have been identified which can only be met by some means of continuous or near continuous observations. Some of the requirements include monitoring of floods, frosts, forest fires, tidal waves, erosion, etc. Such monitoring would be used to assist in the prediction, dissemination of warnings, assessment of damages, and enforcement of controls.

Present and future efforts are to establish the mission requirements and concepts of a SEOS to satisfy earth resources survey and meteorology applications.

The following is a brief description of the SEOS payload.

a. Prime Instrument-LEST - The LEST is a telescope system with an aperture presently specified to be 1.5 meters. It is to be used in the IR. The spectral range will be from 0.2 μm to 15 μm in a series of bands, the specific ranges and bandwidths of which are currently under consideration.

The following subsatellite ground resolutions can be obtained with a 1.5 meter telescope:

Visible	100 meters
Thermal IR	800 meters
Sounding in IR	18 to 30 km

b. Potential Instruments

1. Microwave Sounder - A sounder is being considered that would cover the region of 50 to 220 GHz in five bands. No antenna size has been determined at this time, but the goal is an aperture of 1.5 meters or larger. Resulting ground resolution would range from 220 km at 50 GHz to 50 km at 220 GHz.

2. DSC (Data Collection System) - Data Collection Platforms (DCP's), the SEOS spacecraft, and a Command and Data Acquisition System (CDA) form the fundamental elements of a DCS.

TASK 1AB-3: Determine Maximum Remote Sensing Data Input to BLM by ERS Program.

To provide correlation between the ERS programs that provide repetitive coverage and the BLM lands overflown, the orbits and ground tracks of three ERS satellites were studied. These satellites are ERTS-1, EOS-A and NIMBUS-G. Following is a description of these ground track characteristics by program.

ERTS-1

The ERTS-1 Satellite was launched into a sun-synchronous polar-orbit in July 1972. After post-launch orbital corrections, an orbit was achieved that provided repeat coverage every 18 days and every 251st orbit. The day-light half of the orbit crosses the equator at about 9:30 A.M. local standard time on each orbit with the spacecraft proceeding from North to South. The MSS on ERTS is a four channel scanner that sweeps a swath that is 100 NMI wide from the ERTS orbital altitude. This data is then framed into 100 NMI square images for distribution either in the form of black/white photographs or computer compatible tapes (CCT's). These images are 2,340 lines long with each line containing 3,240 pixels per channel. The images are composed in such a way as to provide 10 percent overlap with the previous and next image along the ground track. The 100 NMI swath width of the MSS results in a 14 percent overlap of images from adjacent orbits at the equator and about 80 percent overlap near the poles.

To correlate the ERTS Image Data with BLM lands, a mylar overlay showing the nominal ERTS orbit ground track has been prepared to the scale of the approximately 40 inch by 40 inch and is superimposed over a BLM Bureau Planning Units map. Figure 4 is a reduction of this 40 by 40 inch map with overlay. Periodic Orbital Drift plus normal orbit decay and subsequent corrections will result in the nominal ground track drifting back and forth across about a 20 NMI strip centered on the nominal orbit track. A typical ERTS Image drawn to the scale of the Planning Units Map is included on the mylar overlay to demonstrate the image size relative to the Map and the image overlap relative to adjacent images. Additional information about ERTS Data formats as well as the ERTS orbit characteristics can be found in the ERTS DATA USERS HANDBOOK. More accurate orbital ground track location data for a given ERTS orbit can be obtained from ERTS User Services at the NASA Goddard Space Flight Center, Greenbelt, Maryland.

EOS-A

The EOS-A satellite is unique in that a concerted effort has been made by the NASA planners to design a payload that will collect data that is responsive to user information needs. Previously such payloads were dictated more by current technology than by the usefulness of the resultant data. The original plans called for EOS-A to be launched in the late 1970's. However, when the results of several user oriented studies were compiled in July 1974 it was discovered that the cost of being responsive to user needs would require slipping this mission to the 1980's. For this reason, along with the fact that current mission plans call for an EOS-A orbit profile identical to that for ERTS-1, a separate mylar overlay for this orbital ground track was not generated. The proposed image format for EOS-A will also be 100 NMI by 100 NMI which will produce the same coverage frequency and percentage of overlap as is realized with ERTS-1. According to current plans there are four projected differences between

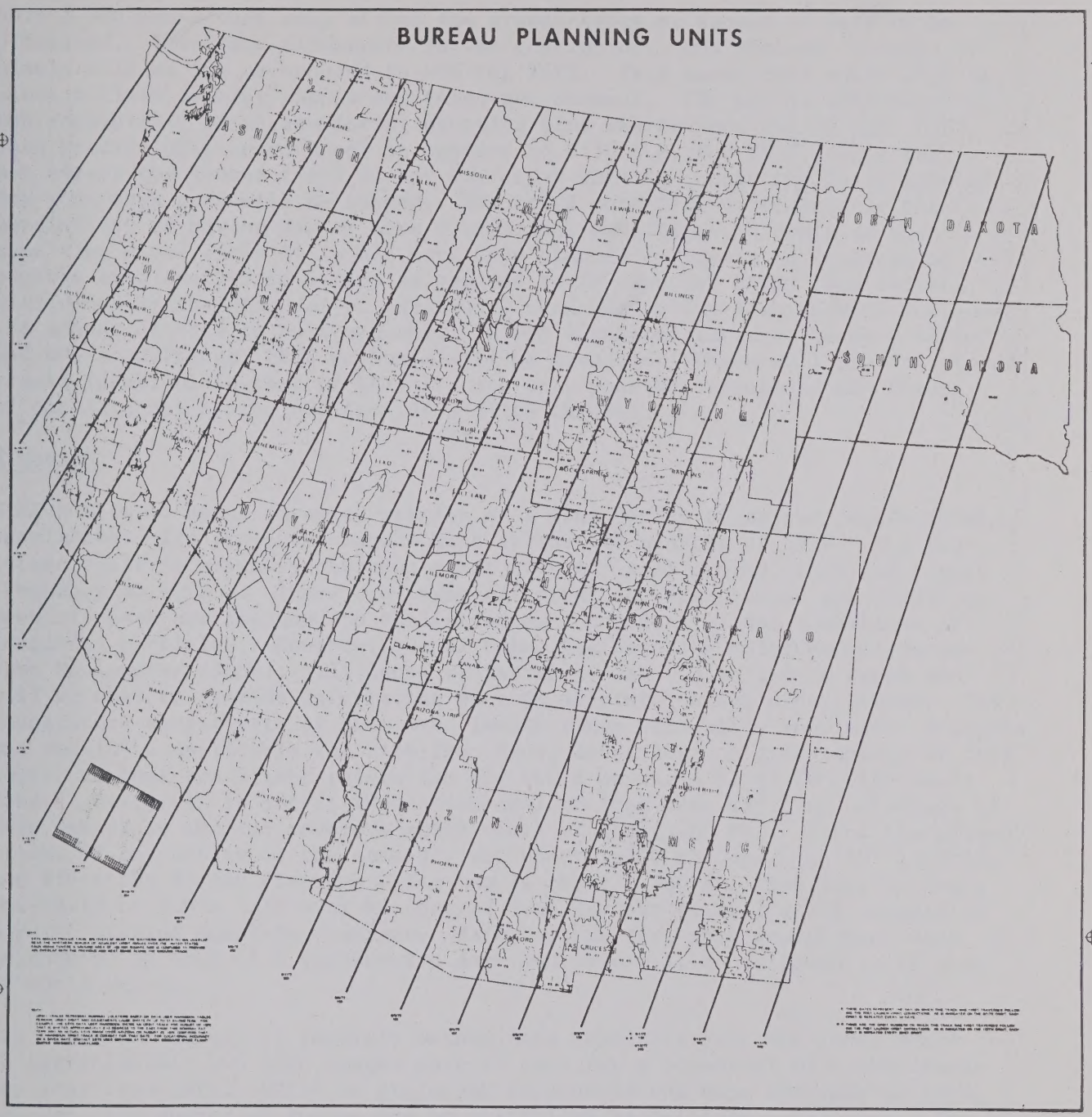

Figure 4. ERTS Orbit Ground Track

ERTS-1 and EOS-A that will affect the ground track or amount of data to be processed. The first difference is the resolution. EOS picture elements or pixels will be 30M as opposed to 80M for ERTS. This means that there will be about 6 times as many pixels per image per channel. The second difference is the possibility of an equitorial crossing time nearer noon (11:00 A.M. has been specifically considered) as opposed to 9:30 A.M. for ERTS. This does not affect the ground track in any way other than to change the local time of day when each area will be imaged. The third potential difference is the possibility of having two or more operational satellites in orbit at the same time whose dates of launch have been planned to result in coverage of a given area every 9 or 6 days as opposed to 18 days for ERTS. The fourth difference is the proposal of additional channels on EOS-A which will increase the amount of data to be processed. In the elongated interval between ERTS-1 and EOS-A additional ERTS payloads will be launched. These will produce ground tracks identical to that of ERTS-1. The only possible change to the format of the data may be the addition of a fifth channel.

NIMBUS-G

NIMBUS-G is to be an advanced version of a long series of weather/environment satellites. Its projected launch date is the 4th quarter of 1978. Its projected orbit is a sun-synchronous orbit with the same ground track and repeat frequency as ERTS-1. There are eight different sensors planned for NIMBUS-G. Most of these are designed to monitor ocean conditions, cloud conditions or suspended particles. However, one of them, the Scanning Multichannel Microwave Radiometer (SMMR), will sense radiation in the 0.8 to 2.8 cm range and will be used to provide information on soil moisture, among other things. The temperature sensitivity of this wave length range will allow snow cover analysis and should be applicable for fire (Hot Spot) detection. A disdavantage of this sensor is that the higher resolution for the 8 channels is 42 KM which would make it difficult to detect areas much smaller than 1764 KM^2. An advantage of this sensor is that it covers a swath width of about 400 NMI. Since the ground tracks of any orbits on the same day are about 1,200 NMI apart at 40° latitude and since the Bureau Planning Units map is about 1,200 NMI from East to West, one-third of BLM's land will be covered each day but it will still require 18 days to provide complete coverage. Said another way, each ground spot will be covered on each of 6 consecutive days but this will be followed by 12 days of non-coverage.

The potential amount of remotely sensed data available over BLM lands would be approximately 200 ERTS images each 18 days for a potential of 4,000 images per year from ERTS. EOS-A is projected to provide the same coverage as ERTS, however, the number of images may be multiplied by multiple satellites. Too little is known about the NIMBUS-G image format to make a similar analysis, however the potential exists for a number of images from this mission equal to that from ERTS-1.

TASK 1AB-4: Estimate Actual ERS Data Available to BLM.

To analyze the affect of cloud cover on the potential number of useful ERTS images available over BLM lands, an annual percentage of cloud cover map for the U.S. was examined. Such a map by month and year was located in the CLIMATIC ATLAS OF THE UNITED STATES. Copies of the maps are included as a product of this study. Table 4 has a summary of the cloud cover factor for each BLM district.

Table 4. Orbit Passes to Cover BLM Districts Per Satellite Program

	ERTS-1 MSS	EOS-A TM*	NIMBUS-G SMMR	Cloud Cover Factor**
Albuquerque	5	5	1	46
Arizona Strip	2	2	1	36
Baker	3	3	1	59
Bakersfield	4	4	1	38
Burley	3	3	1	60
Battle Mountain	3	3	1	44
Billings	3	3	1	62
Boise	3	3	1	58
Burns	2	2	1	56
Canon City	4	4	1	47
Carson City	2	2	1	40
Casper	4	4	1	52
Cedar City	2	2	1	46
Coeur d'Alene	3	3	1	66
Coos Bay	1	1	1	68
Craig	3	3	1	55
Dillon	3	3	1	59
Elko	3	3	1	50
Ely	2	2	1	48
Eugene	2	2	1	68
Fillmore	2	2	1	47
Folsom	4	4	1	37
Grand Junction	3	3	1	45
Idaho Falls	3	3	1	59
Kanab	2	2	1	47
Lakeview	3	3	1	54
Las Cruces	4	4	1	34
Las Vegas	4	4	1	37
Lewistown	3	3	1	58
Malta	6	6	1	62
Medford	2	2	1	58
Missoula	4	4	1	70
Monticello	3	3	1	48
Montrose	2	2	1	55
Miles City	4	4	1	55
Phoenix	5	5	1	32
Price	2	2	1	52
Prineville	2	2	1	63
Rawlins	5	5	1	51
Redding	2	2	1	43
Richfield	2	2	1	52
Riverside	4	4	1	32
Rock Springs	3	3	1	60
Roseburg	2	2	1	66
Roswell	3	3	1	41
Safford	2	2	1	33
Salem	3	3	1	69

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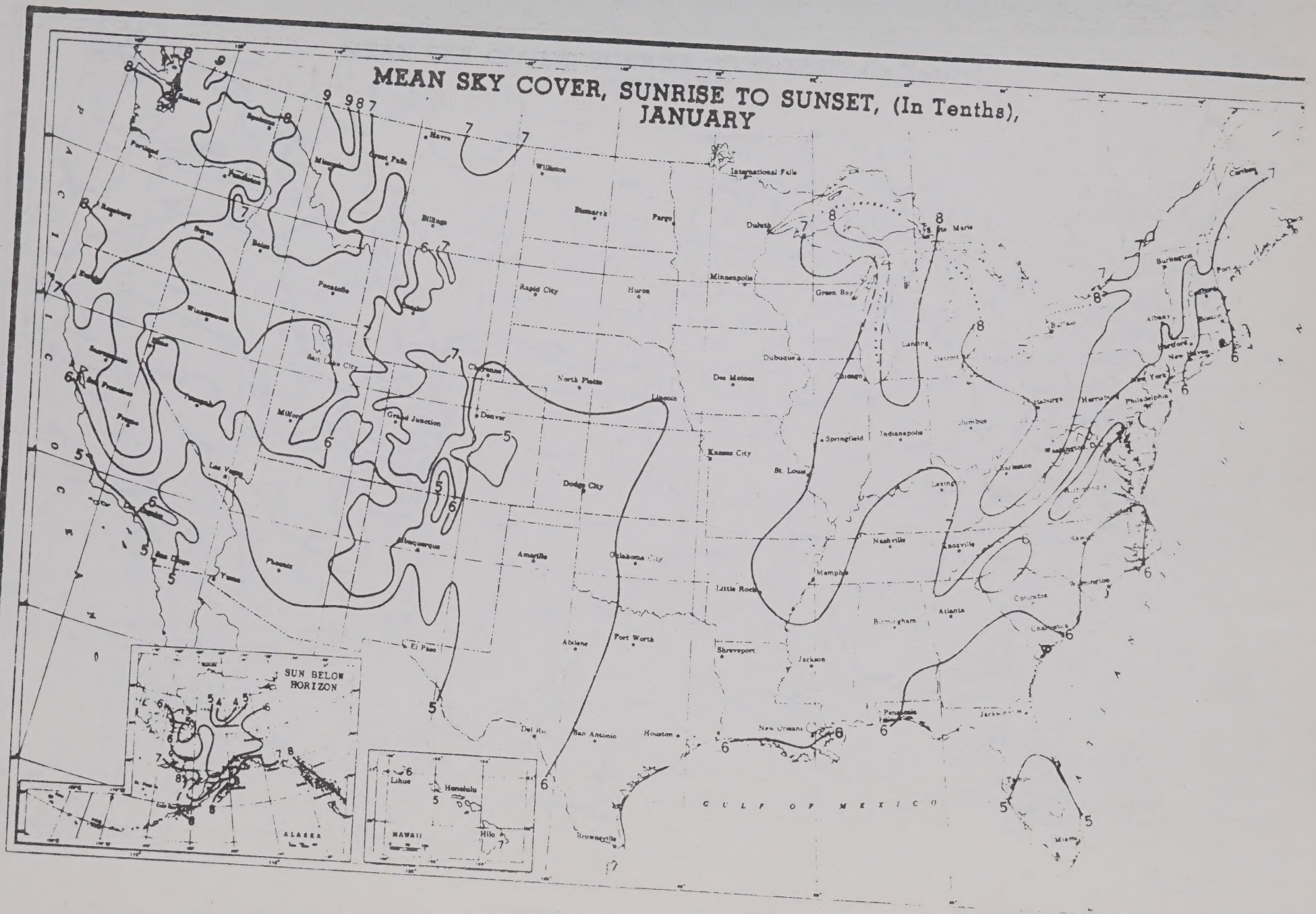
Table 4. (Continued)

	ERTS-1 MSS	EOS-A TM*	NIMBUS-G SMMR	Cloud Cover Factor**
Salmon	2	2	1	71
Salt Lake City	4	4	1	52
Shoshone	2	2	1	65
Socorro	2	2	1	60
Spokane	6	6	1	62
Susanville	2	2	1	46
Ukiah	3	3	1	52
Vale	2	2	1	56
Vernal	2	2	1	50
Worland	3	3	1	60
Winnemucca	2	2	1	46
Yuma	2	2	1	18

*Current mission plans call for EOS-A to have a ground track pattern identical to ERTS-1. More frequent coverage may be achieved by using multiple vehicles simultaneously.

**Cloud cover factors are in annual percent of sky cover between sunrise and sunset.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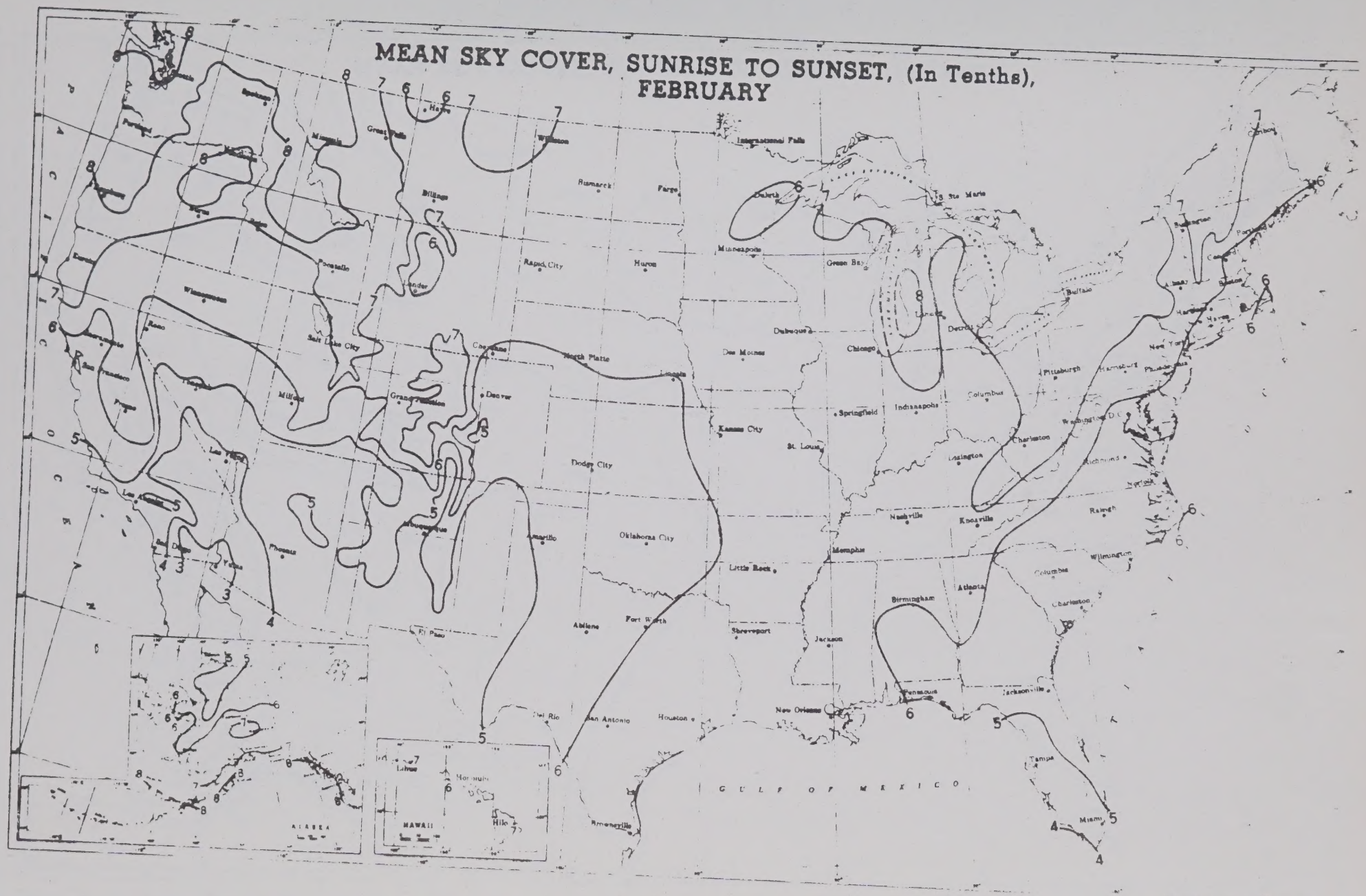
GULF OF MEXICO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Sault Ste Marie
Rapid City
Huron
Grand Rapids
Green Bay
Buffalo
Boise
Salt Lake City
Casper
North Platte
Omaha
Dubuque
Des Moines
Chicago
Detroit
Cleveland
Pittsburgh
Harrisburg
Philadelphia
New York
Reno
San Francisco
Denver
Kansas City
Springfield
Indianapolis
Columbus
Washington D.C.
Charleston
Richmond
Norfolk
Las Vegas
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St. Louis
Lexington
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Jacksonville
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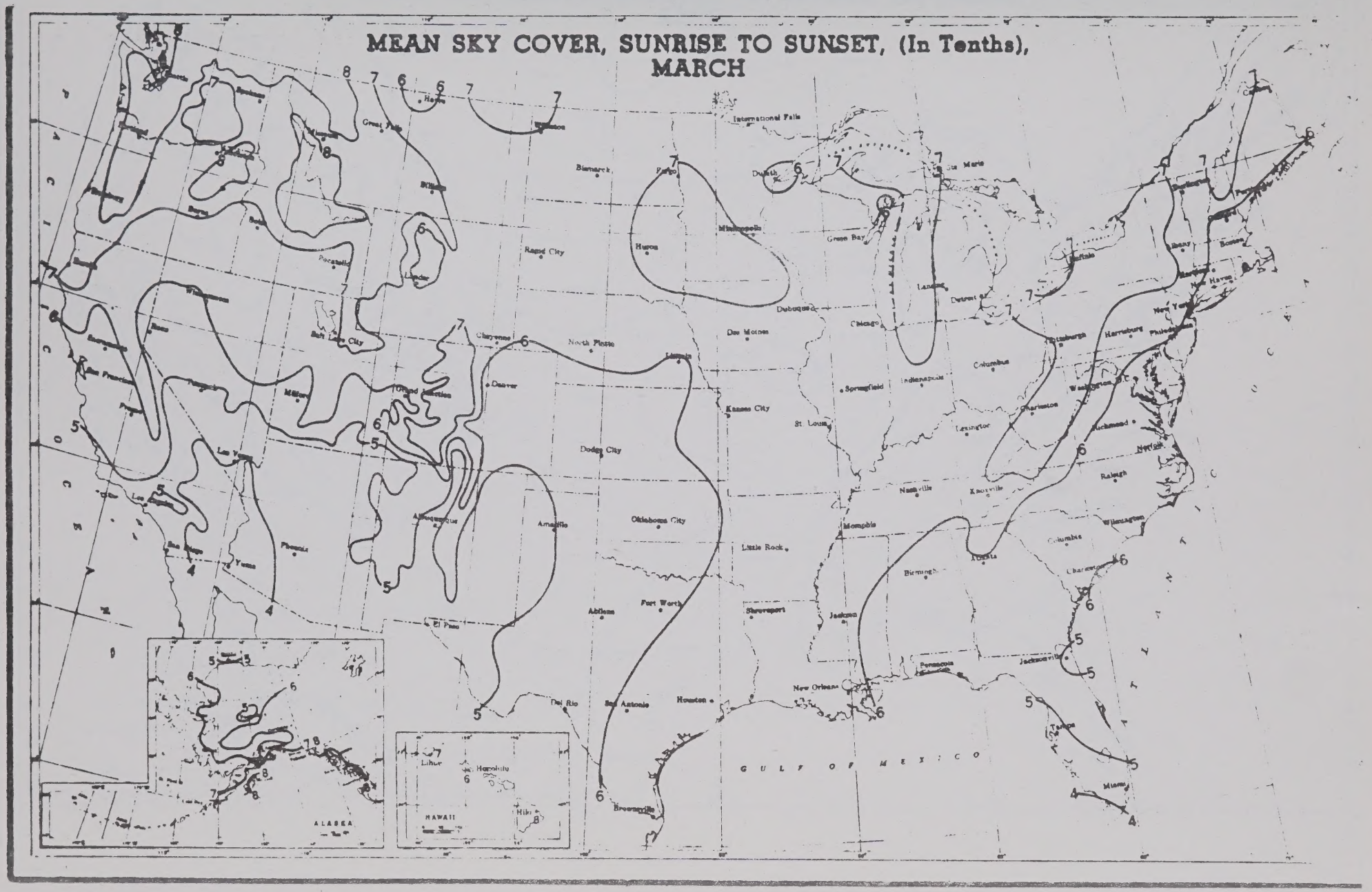
MEAN SKY COVER, SUNRISE TO SUNSET, (In Tenths),
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Bismarck
Fargo
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Chicago
Des Moines
Cheyenne
North Platte
Lincoln
Denver
Kansas City
St. Louis
Springfield
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Columbus
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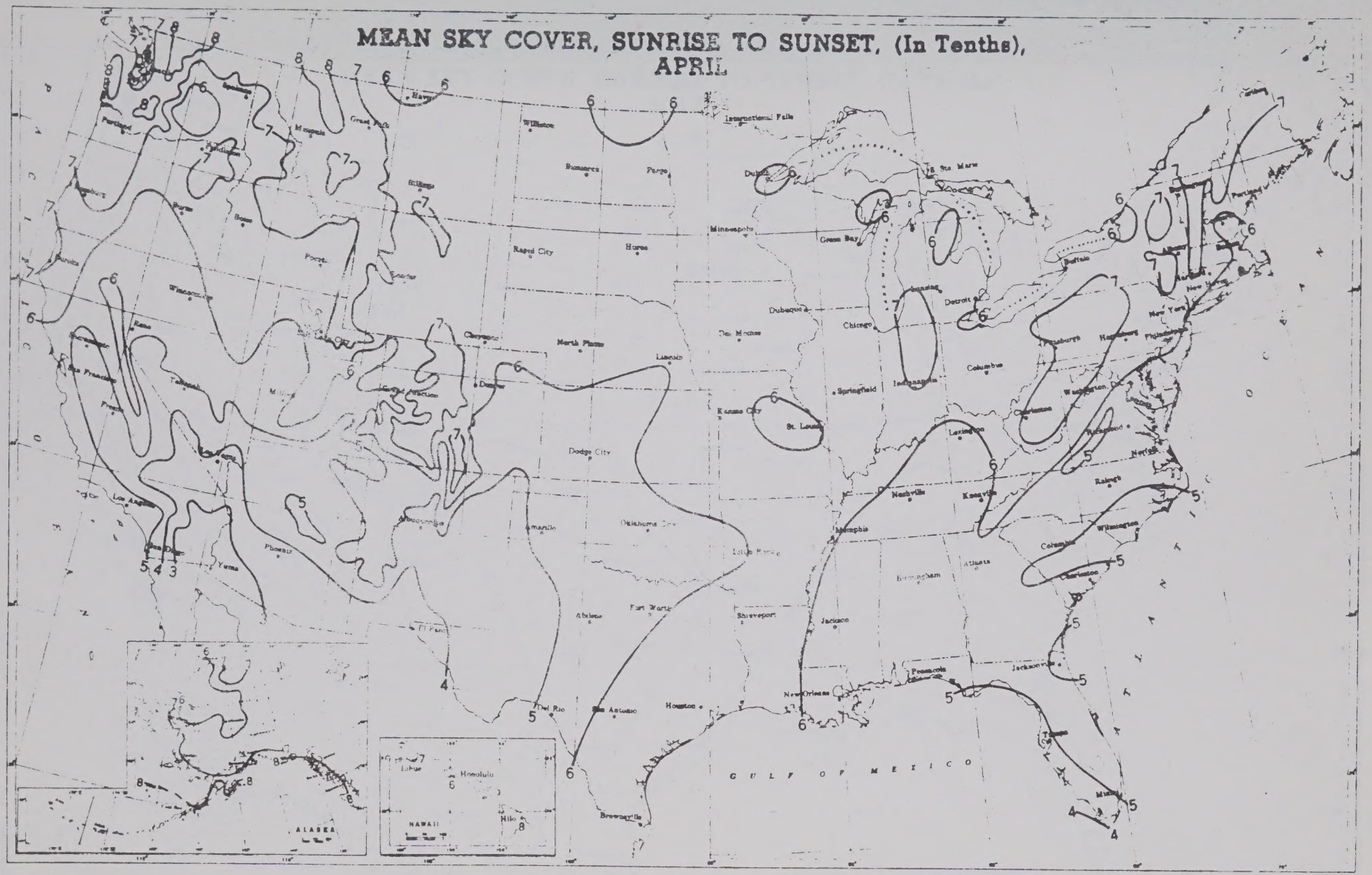
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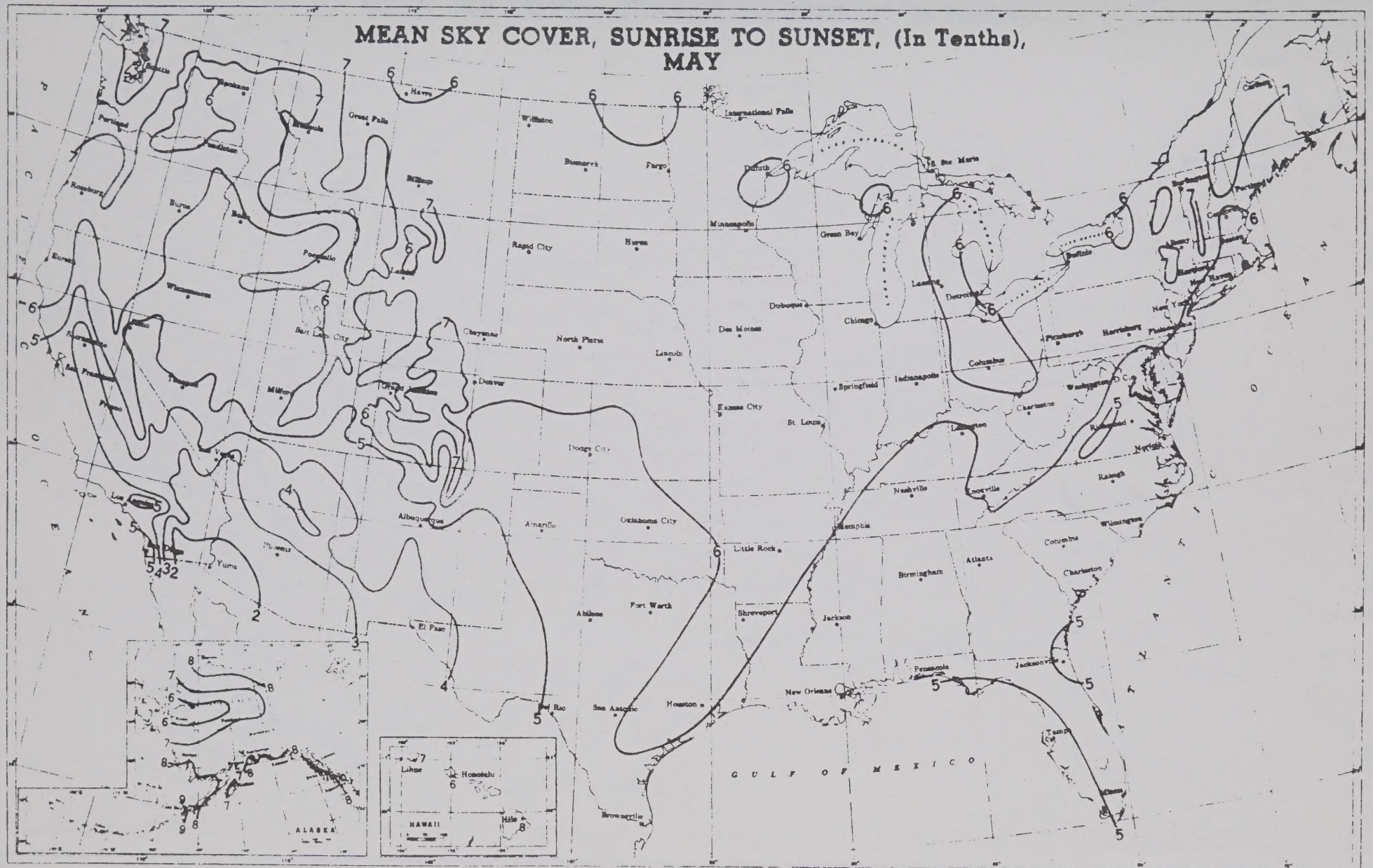
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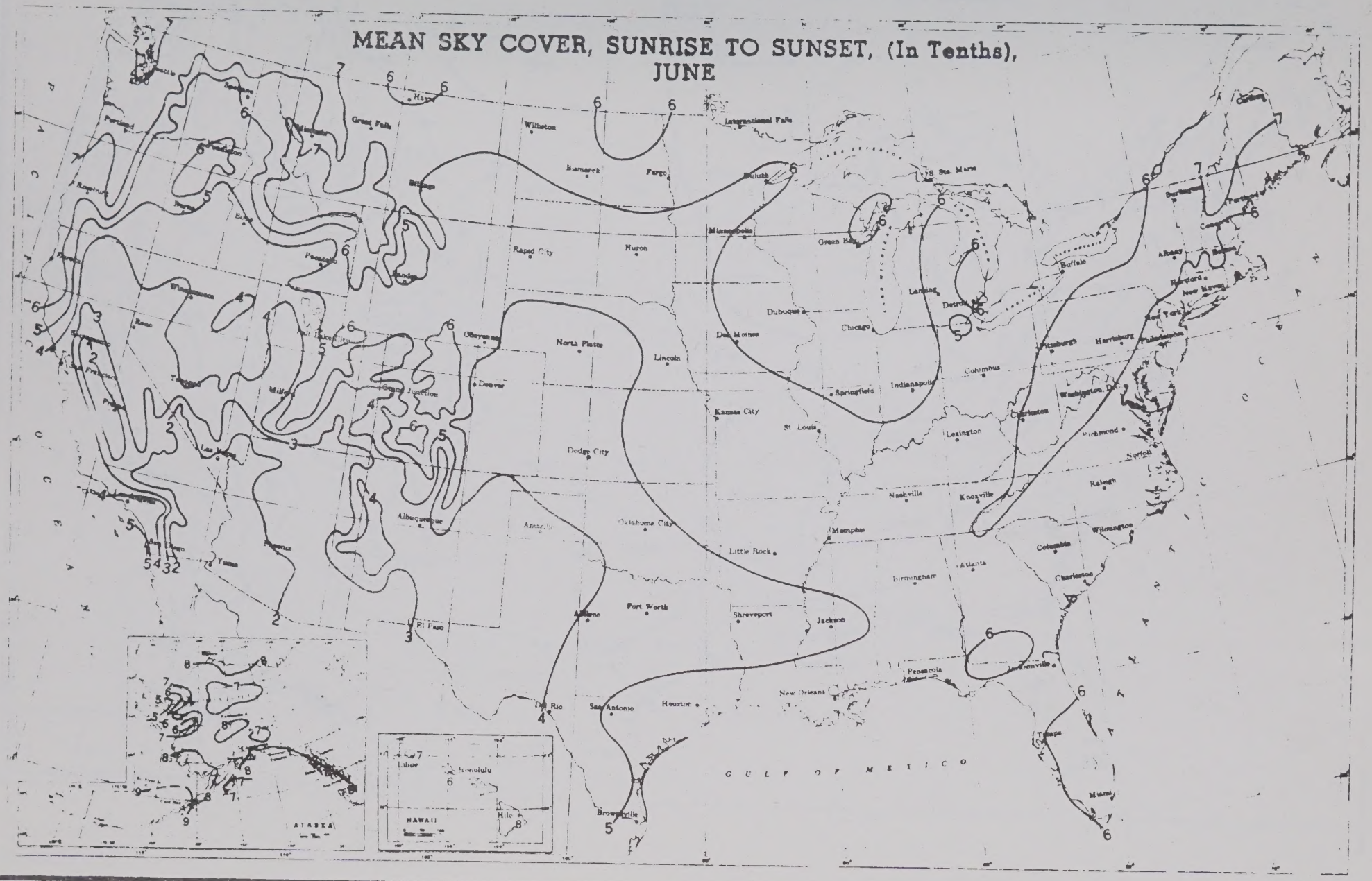

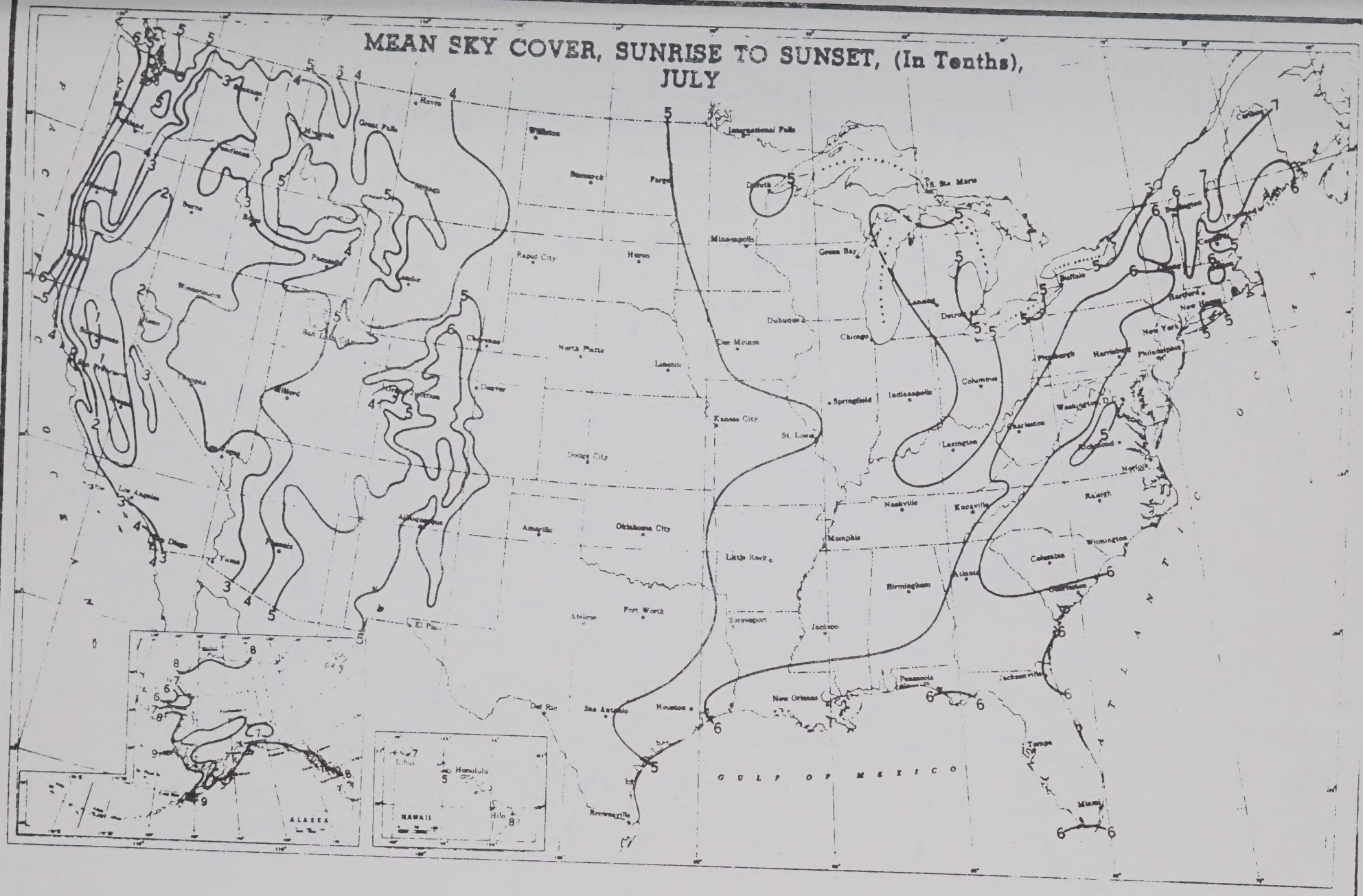
MEAN SKY COVER, SUNRISE TO SUNSET, (In Tenths),
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Lansing
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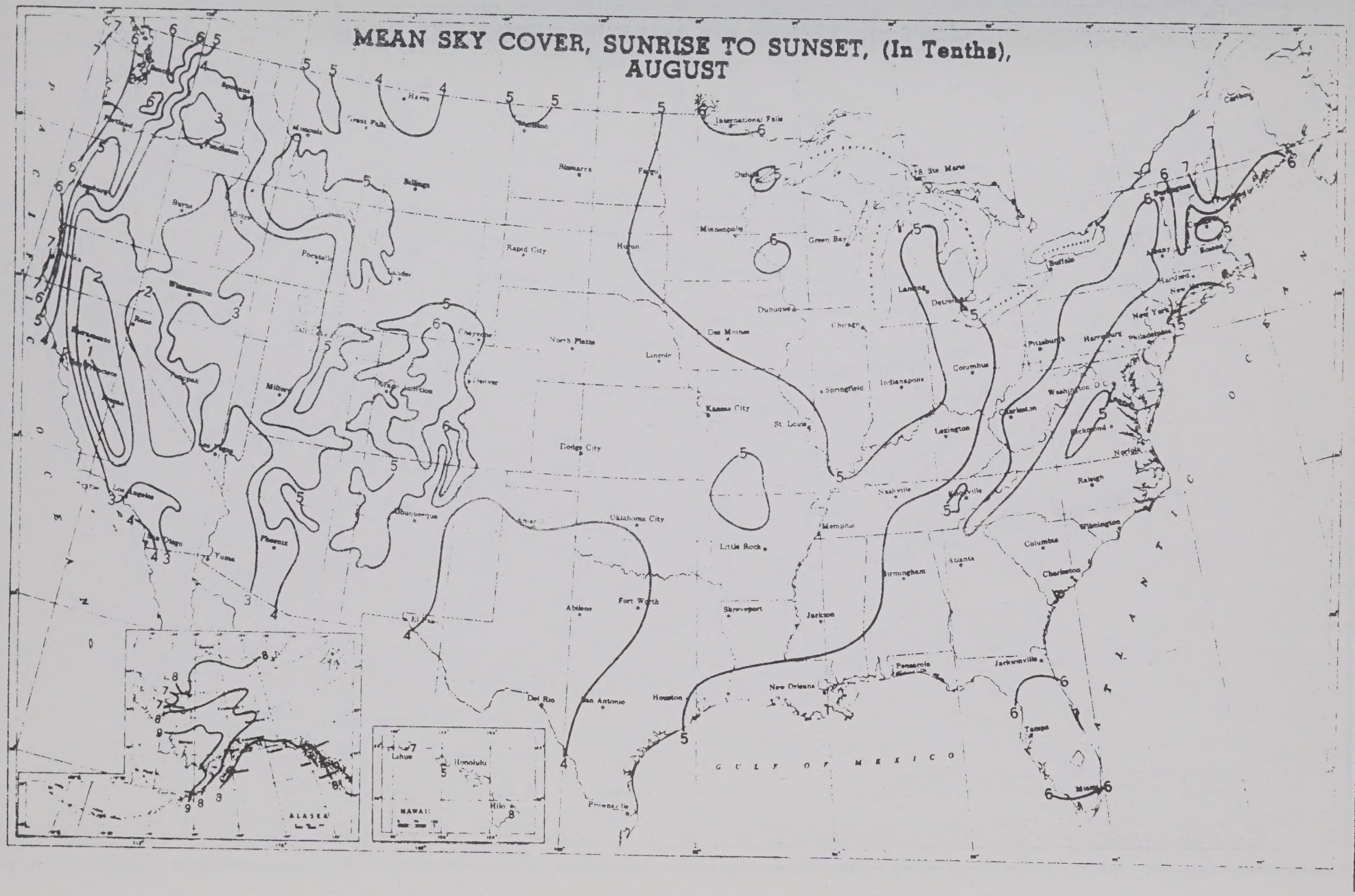
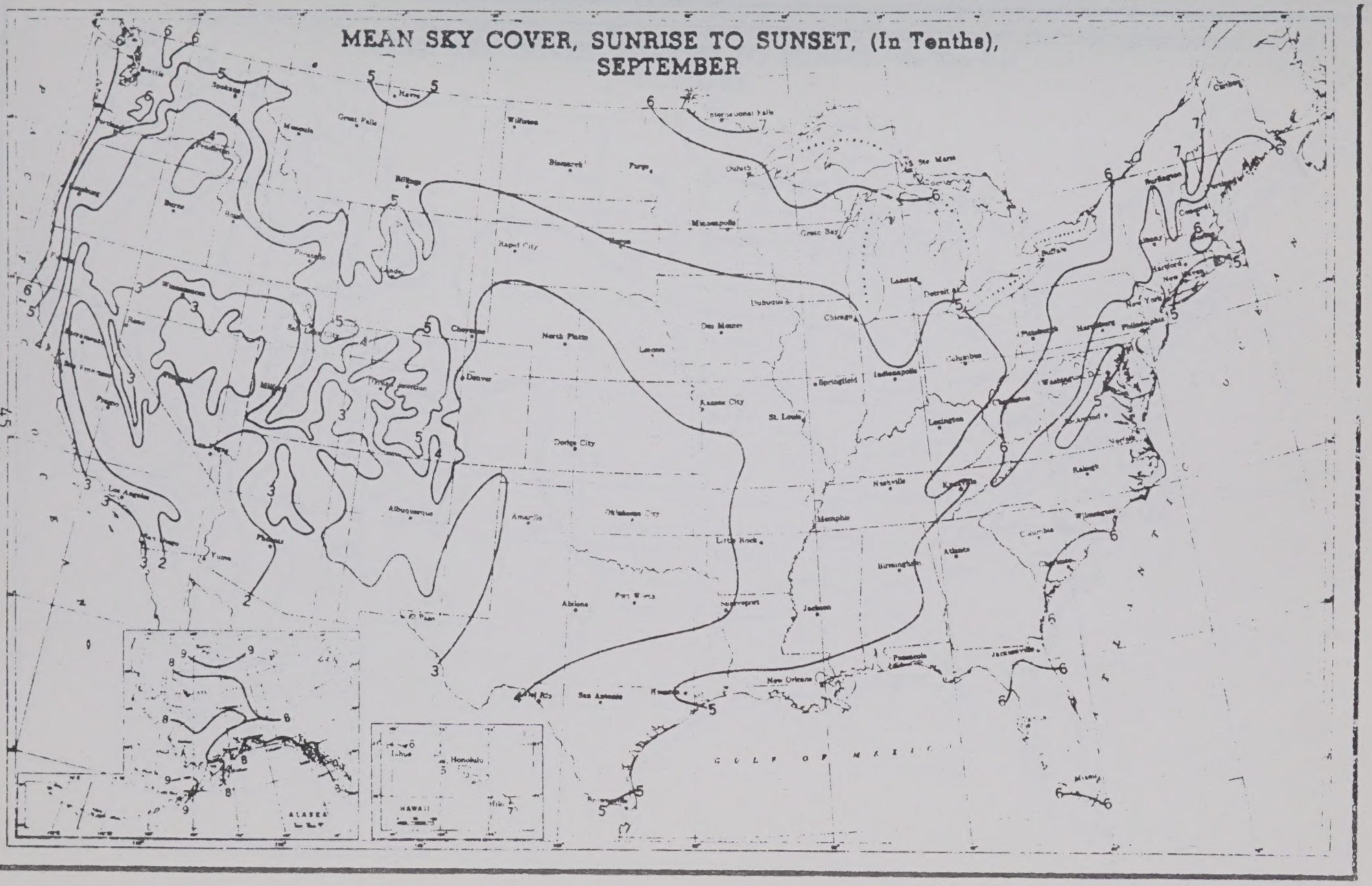
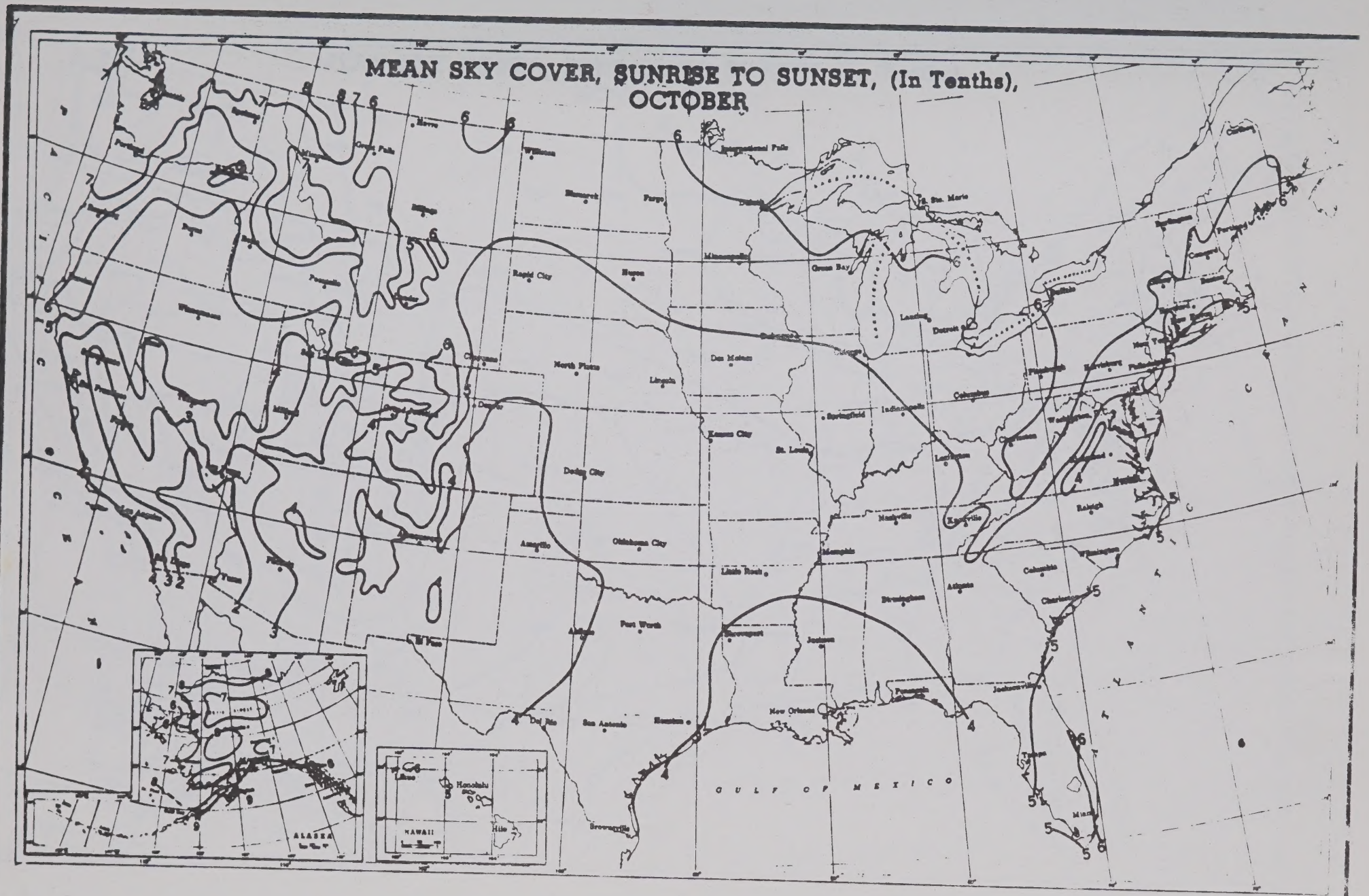
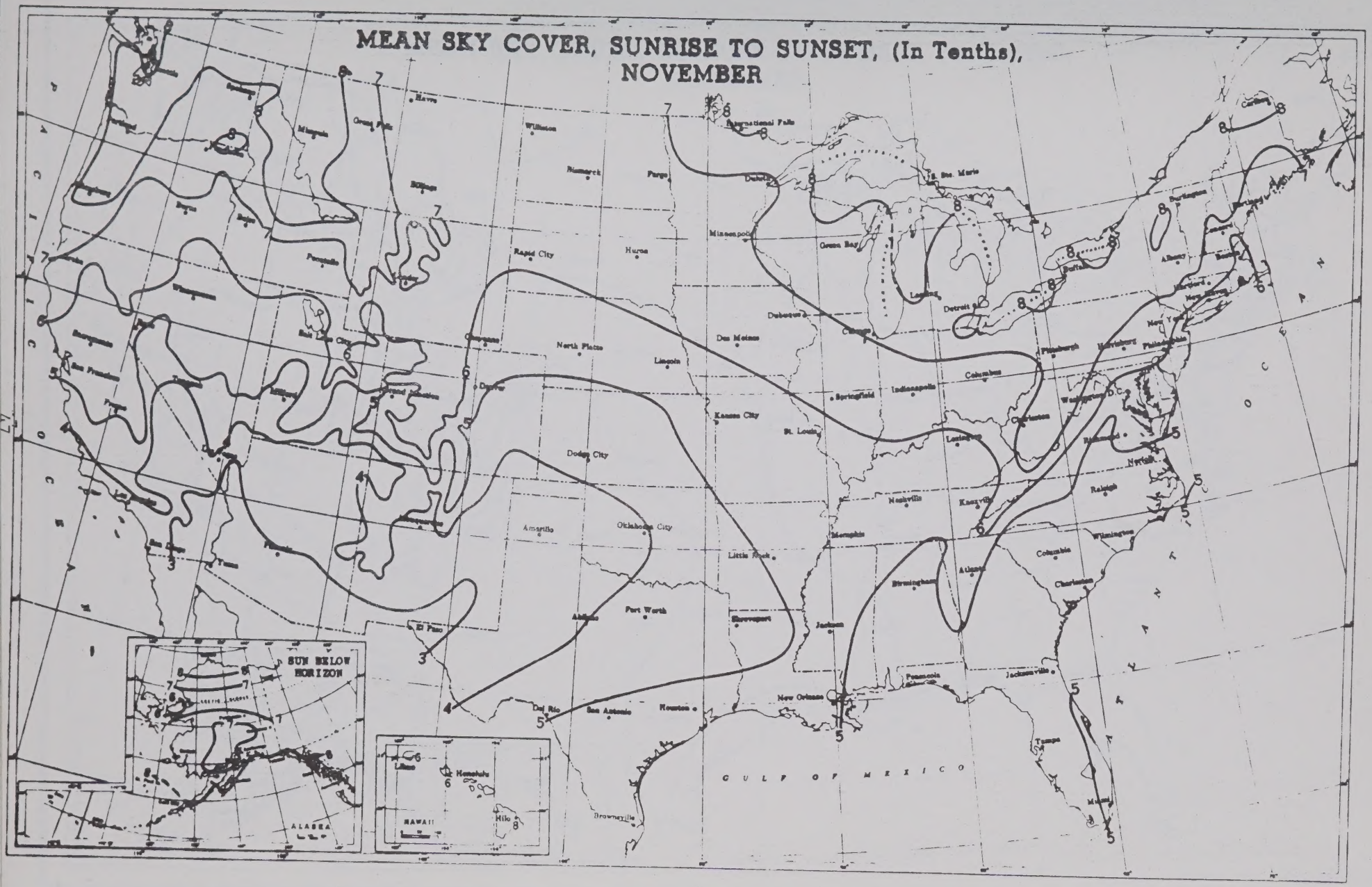
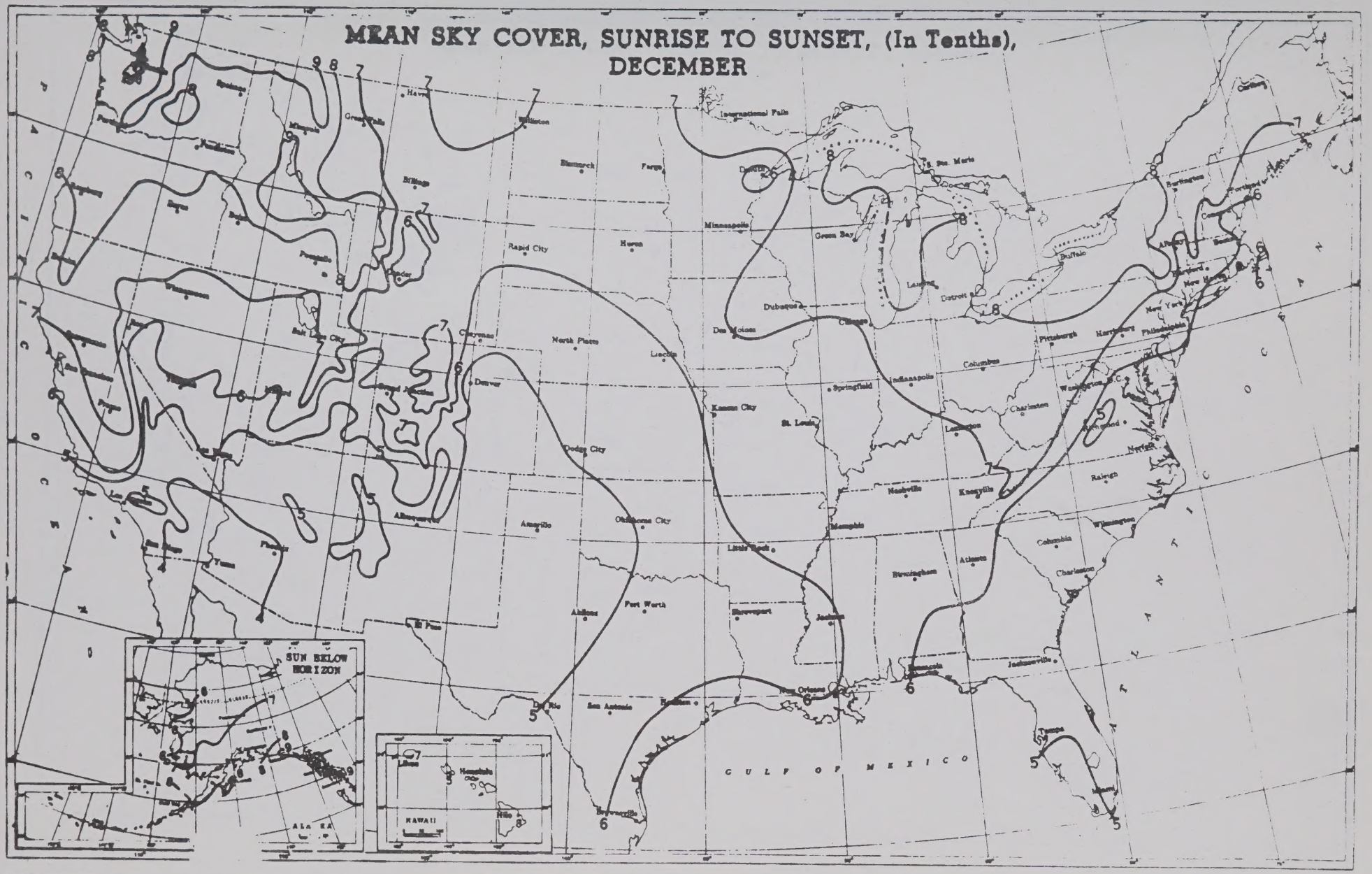

MEAN SKY COVER, SUNRISE TO SUNSET, (In Tenths),
AUGUST
Havre
Great Falls
Glasgow
International Falls
Bismarck
Fargo
Duluth
Minneapolis
Green Bay
Billings
Burns
Rapid City
Huron
Buffalo
Pocatello
Lander
Dubuque
Lansing
Detroit
Cheyenne
Chicago
North Platte
Des Moines
Lincoln
Pittsburg
Harrisburg
Philadelphia
Columbus
Denver
Springfield
Indianapolis
Kansas City
Charleston
Washington D.C.
St. Louis
Richmond
Lexington
Dodge City
Norfolk
Raleigh
Nashville
Albuquerque
Oklahoma City
Memphis
Wilmington
Little Rock
Columbus
Atlanta
Birmingham
Charleston
Phoenix
Yuma
Abilene
Fort Worth
Shreveport
Jackson
Jacksonville
Pensacola
New Orleans
Del Rio
San Antonio
Houston
Tampa
GULF OF MEXICO
Miami
Brownsville
ALASKA
Lihue
Honolulu
HAWAII
Hilo

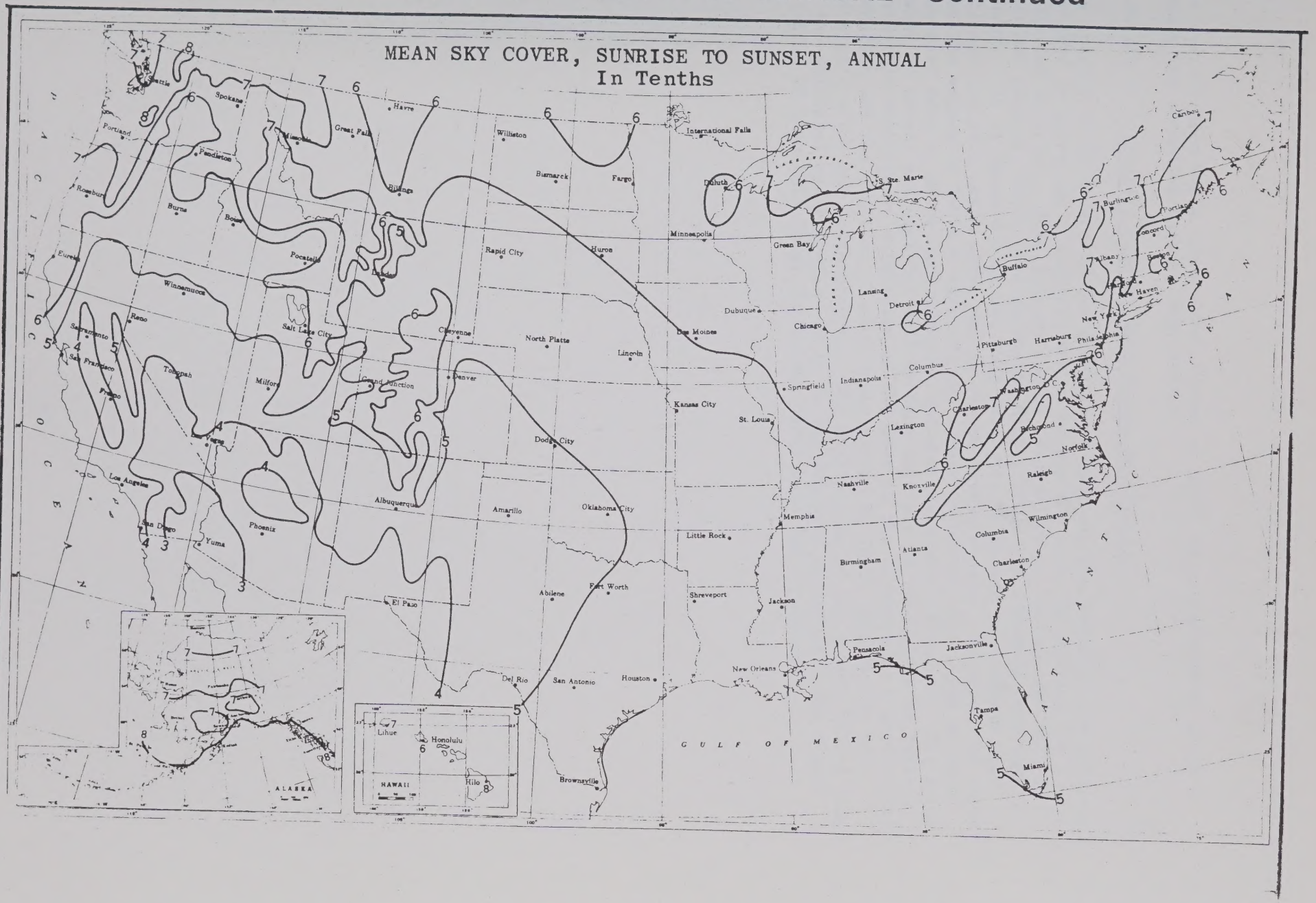
MEAN SKY COVER, SUNRISE TO SUNSET, (In Tenths), SEPTEMBER




MEAN SKY COVER, SUNRISE TO SUNSET, (In Tenths),
OCTOBER
GULF OF MEXICO
ALASKA
HAWAII
Honolulu
Hilo


MEAN SKY COVER, SUNRISE TO SUNSET, (In Tenths),
NOVEMBER
SUN BELOW HORIZON
ALASKA
HAWAII
Honolulu
Hilo
GULF OF MEXICO


MEAN SKY COVER, SUNRISE TO SUNSET, (In Tenths),
DECEMBER
SUN BELOW HORIZON
HAWAII
GULF OF MEXICO


MEAN SKY COVER, SUNRISE TO SUNSET, ANNUAL
In Tenths
Seattle
Spokane
Portland
Pendleton
Roseburg
Burns
Eureka
Winnemucca
Reno
Sacramento
San Francisco
Fresno
Los Angeles
San Diego
Yuma
Phoenix
Las Vegas
Tonopah
Milford
Salt Lake City
Pocatello
Boise
Great Falls
Havre
Billings
Miles City
Wilhelm
Bismarck
Fargo
Rapid City
Huron
Cheyenne
North Platte
Grand Junction
Denver
Albuquerque
Amarillo
Dodge City
Lincoln
Kansas City
Oklahoma City
Abilene
Fort Worth
El Paso
Del Rio
San Antonio
Houston
Brownsville
Little Rock
Shreveport
Jackson
New Orleans
Memphis
St. Louis
Springfield
Des Moines
Dubuque
Chicago
Minneapolis
International Falls
Duluth
Green Bay
Lansing
Detroit
Buffalo
Canton
Burlington
Concord
Albany
Boston
Haven
New York
Pittsburgh
Harrisburg
Philadelphia
Washington D.C.
Columbus
Indianapolis
Lexington
Charleston
Richmond
Norfolk
Raleigh
Nashville
Knoxville
Wilmington
Columbia
Charleston
Atlanta
Birmingham
Pensacola
Jacksonville
Tampa
Miami
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
ALASKA
HAWAII
Lihue
Honolulu
Hilo

The overall area has a cloud cover factor of about 51 percent which would reduce the potential data by this factor.

TASK 1AB-5: Identify Mission Data Passes Per District.

The purpose of this part of the study is to indicate the minimum time interval involved in gathering a complete set of images for each ERS mission for a given BLM District. This information is tabularized in Table 4 for ERTS-1 (the MSS sensor), EOS-A (the Thermatic Mapper (TM)) and NIMBUS-G (the SMMR sensor). It is assumed that the SMMR data will be imaged in a format that will use the full swath width and is approximately square. It should be noted that the values in Table 4 indicate the number of orbits, i.e., the minimum number of days to cover each district and not the number of images. The actual number of images per district will be some multiple of the values in Table 4 where this multiple is a function of the size of the district in a north/south direction and the position of each image along the orbit relative to the district's north and south borders. The positioning of the sample ERTS-1 image of the delivered mylar overlay is in no way intended to indicate the actual location of some ERTS image during the orbit used for the example.

TASK 1AB-6: Determine Potential ERS Data Input by BLM Activity

Remote sensing (airborne & spaceborne) has the potential for revolutionizing the detection and characterization of many mineral, range, forestry and watershed phenomena. Recent studies indicate that remote sensing techniques can be used in the ultra violet, visible, infrared, and microwave regions of the electromagnetic spectrum to collect data that gives a measure of the reflectance, emittance, surface geometry, and equivalent block body temperature of plants and soils. With a minimum amount of ground truth this data will permit (a) identification and area measurements of vegetative types; (b) mapping of disease and insect invasion; (c) mapping of soil associations; (d) mapping of forest types; (e) mapping of forest fire boundaries; (f) mapping of areas of high potential forest fire hazards; (g) assessment of crop and timber stand vigor; (h) delineation of range land productivity.

Effective management of BLM calls for large masses of information. Unfortunately, much of the existing information is inadequate, and much that is needed has never even been collected (only a few BLM planning units have collected color IR photography from low and medium level aircraft flights), and the job of collecting the needed information is time consuming and expensive. Although remote sensing by itself cannot acquire all types of information needed by BLM functions, such as plant record and/or tree record, which definitely require the extensive support of ground truth (spot coverage) information, it does appear capable of doing much of the mass job satisfactorily. It has definitely the potential for providing accurate and timely information on which to base important management and economic decisions.

It is important that BLM should capitalize on current satellite technology such as the ERTS-1 and ERTS B which has been recently renamed as LANDSAT 1 and LANDSAT 2 respectively. Each of those satellite orbits allows repetitive coverage every 18 days of each scene at the same local solar time, and together (LANDSAT 1 and LANDSAT 2) provide an effective repeat time of 9 days. Results of those satellites are currently being studied by some 500 investigators. Their studies encompass a broad range of investigations related to such disciplines as agriculture, forestry and range land; mineral and land resources; water resources; land use ecology and environmental quality, mapping and charting, all of them are within the functions of the BLM operation. Initial results of the 500 investigators indicate that LANDSAT data is a valuable supplement to information collected by conventional means.

It is believed that BLM applications such as soil mapping, range and watershed management can be more efficient if a hybrid set-up of multispectral scanner data from satellites, in conjunction with color IR photography obtained from low and medium level aircraft flights, is utilized.

Moreover, broadscale features, such as geological fault patterns, not discernible from lower altitudes, became apparent. In addition, satellite paths made it possible to cover far reaching areas which were not readily accessible, and in which it was economically infeasible to acquire the data by airplane. The characteristics of satellite orbits made it practical to repeat observations of the same areas frequently, and thus to monitor temporal variations of geological phenomena. In addition to its remote sensing capability, the satellite has a retransmission capability which allows users to obtain data from remote in situ sensors quickly and without costs associated with land-based communications. Platform data become available within 24 hours of their acquisition. As of mid-1974 approximately 150 Data Collection Platforms (DCP) were in operation. This system makes it feasible for the first time to monitor the level of activity at widely separated volcanoes (geological hazards BLM Procedure #7311) and to relay this data rapidly to one central office for analysis. Before LANDSAT was launched, only a few volcanoes in the world were monitored continuously because of the high cost of building and staffing volcano observatories. Yet it is known from data collected in this century that while visible signs of pending eruptions may only occur minutes to days in advance, invisible but measurable signs may be detected days, weeks, months, and even years before a major eruption. While prediction of specific eruptions is still an evasive goal, early warning of a reawakening of quiescent volcanoes is now a distinct possibility.

Table 5 and 6 provide background for the above assessment by summarizing the characteristics of LANDSAT 1 and LANDSAT 2 and the planned characteristics of ERTS-C and EOS.

Table 7 describes the suitability of remote sensing technology (airborne and spaceborne) as applied to BLM functions. Column 2 of Table 7 defines the BLM functions as they are related to the BLM procedure numbers in column 1. Definition and description of the menu types of each function, and their associated aerial photography scales given in column 3 were derived from meetings with BLM personnel.

Ranking of suitability for acquisition and processing of color IR photography obtained from low and/or medium level aircraft flights were derived from the experience of BLM personnel concerning several of their planning units remote sensing operations. In this operation, the low level flights for spot coverage used a 35 mm camera for color IR photography, and together with ground truth information provides the needed resolution for plant or plot records of range and forest management. (A plant record is used to derive the age or size of an individual tree, and a plot record may be used to derive the stand vigor of 1/2 acre plot.) As long as the low level (35 mm) aircraft flight remote sensing operation remains to be used discriminately for spot coverage, it should provide the best resolution and most efficient operation for plant and plot records.

The medium level flight with 9" X 9" camera is mostly used for small area coverage of up to 20 acres, and for large spot coverages. Its resolution for plant records is poor compared to the 35 mm camera of low level flights, but good for plot records. The 9" X 9" camera usage is more efficient for plot records and small area coverage as compared to the 35 mm camera of low level flights.

Table-5 Advanced Earth Resources Satellite Systems: Status of Programs

Program	Nation	Objectives	Alt. (km)	Inclination (deg.)	Effective Repeat Time (Day)	Prospective First Launch	Status
Earth Resources Technology Satellite (ERTS-B	U.S.	Maintain continuity of ERTS-1 earth resources data	920	99	18	1Q1975	In construction
Advanced Earth Resources Technology Satellite (ERTS-C)	U.S.	Maintain continuity and expand spectral range of ERTS-1 earth resources data	920	99	18	1978	Sensors in development. May be merged with ERSOS
Earth Observation Satellite (EOS)	U.S.	NASA's main effort in "next generation" earth resources satellite, to generate data with 8 times better spatial resolution than ERTS-1, with improved spectral resolution	914	99	18	1979	Feasibility studies completed. Sensor developments and system definition studies underway
Sychronous Meteorological Satellite (SMS)	U.S.	Demonstrate capability for near continuous observation of cloud patterns and major storms, also operational system for collecting/distributing measurement from data collection platforms.	35,870		20 (minutes)	1974	SMS-1 launched May 1974. SMS-B scheduled for launch 4Q 1975.

Table-6 Advanced Earth Resources Satellite Systems: Prospective Sensor and Data Reception Characteristics

PRINCIPAL EARTH RESOURCES REMOTE SENSORS								DATA RECEPTION		
Program	Instrument	Spectral Range (microns)	Field of View (km)	Swath Width (km)	Spatial Resolution at Nadir Instantaneous Field of View (m)	Notes	Complementary Sensor Data Collection System and Atmospheric Measurement Devices	On-Board Storage	Peak Data Rate 10^6 bit	Data Carrier Frequency (GHz)
ERTS-B	Return Beam Vidicon (RBV) Camera	Band 1: 475-.575 Band 2: 580-.680 Band 3: 698-.830	185x185		80		Data collection system, same as ERTS-1	Yes	Analog	S-band
	Multispectral Scanner (MSS)	Band 4: .50-60 Band 5: .60-70 Band 6: .70-80 Band 7: .80-1.10		185	79				16	
ERTS-C	RBV Camera	Similar to ERTS-B				Possibly two cameras will be carried to provide stereo coverage	Data collection System	Yes	Analog	S-band
	MSS	Similar to ERTS-B with an additional thermal infrared channel (10.4-12.6 microns). Spatial resolution of thermal channel is 240 meters.								

Table-6 Advanced Earth Resources Satellite Systems: Prospective Sensor and Data Reception Characteristics - Continued

PRINCIPAL EARTH RESOURCES REMOTE SENSORS								DATA RECEPTION		
Program	Instrument	Spectral Range (microns)	Field of View (km)	Swath Width (km)	Spatial Resolution at Nadir Instantaneous Field of View (m)	Notes	Complementary Sensor Data Collection System and Atmospheric Measurement Devices	On-Board Storage	Peak Data Rate 10^6 bit	Data Carrier Frequency (GHz)
EOS	Thematic Mapper (TM)	Band 1: .5-6 Band 2: 6-7 Band 3: .7-8 Band 4: .8-11 Band 5: 1.55-1.75 Band 6: 2.08-2.35 Band 7: 10.4-12.6		185 185	30-50 30-50 90-150		Data collection System: design to emphasize high traffic capacity and simple lowcost platforms.	No	240	X-band
	High Resolution Pointable Imager (HRPI)	Band 1: .5-6 Band 2: .6-7 Band 3: .7-8 Band 4: .8-1.1		48	10	HRPI will have an offset pointing capability				
	Synthetic Aperture Radar (SAR)	X-band L-band		40	30					

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 1 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
3000	MINERALS MANAGEMENT										
3030	MINERALS RESOURCE INVENTORY										
	Develop and maintain a systematic and comprehensive inventory of mineral resources on the public lands.										
	Deposit (Mining - Area Coverage)										
	o Type	1:250,000	VP	VP	G	G	G	VG	G	VG	
	o Acres	1:250,000	VP	VP	G	G	G	VG	G	VG	
	o Formation	1:250,000	VP	VP	G	G	G	VG	G	VG	
	Field Record (Mining - Area Coverage)										1,2,3, 4,5,6
	o Total Reserve	1:250,000	VP	VP	G	G	G	VG	G	VG	
	o Acreage	1:250,000	VP	VP	G	G	G	VG	G	VG	
	Field Record (Gas/Oil - Spot Coverage)										
	o Acreage	1:24,000	G	G	-	-	-	-	P	F	
	o Number of Wells	1:24,000	G	G	-	-	-	-	VP	P	

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 2 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
3509	SURFACE MANAGEMENT REQUIREMENTS (Spot Coverage) Conduct field inspections to ensure that the terms of the permit/lease are observed insofar as they relate to surface disturbance and reclamation stipulations.	1:5,000	VG	G	-	-	-	-	VP	P	1,2,3, 4,5,6
4000	RANGE MANAGEMENT										
4412	PHYSICAL RESOURCE STUDIES Conduct forage surveys to estimate the current grazing capacity for livestock and wildlife. Vegetation inventory data is used to determine stocking rates and is useful in estimating grazing capacity. Plant Record (Spot Coverage)										
	o Species Description	1:5,000	VG	P	-	-	-	-	VP	P	
	o Plant Vigor	1:5,000	VG	P	-	-	-	-	VP	P	
	o Age or Size	1:5,000	VG	P	-	-	-	-	VP	P	
	o Disease, Insects, or Parasites	1:5,000	VG	P	-	-	-	-	VP	P	

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 3 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
	Plot/Transect Record (Spot Coverage)										
	o Composition of Plot by Species	1:24,000	G	G	-	-	-	-	P	F	
	o Vegetation Trend	1:24,000	G	G	-	-	-	-	P	F	1,2,7,
	o Stand Vigor	1:24,000	G	G	-	-	-	-	P	F	8,9,10,
	o Utilization Information										11,12,
	- Annual Use	1:24,000	G	G	-	-	-	-	P	F	13,14,
	- Fire	1:24,000	G	G	-	-	-	-	P	F	15,16,
	o Percentage of Bare Ground	1:24,000	G	G	-	-	-	-	P	F	17,18,
	o Percentage of Litter	1:24,000	G	G	-	-	-	-	P	F	19
	o Disease, Insects, or Parasites	1:24,000	G	G	-	-	-	-	P	F	
	o Seeding or Planting Information	1:24,000	G	G	-	-	-	-	P	F	
	Vegetative Type Record (Area Coverage)										
	o Composition of Type by Species	1:125,000	VP	P	G	G	G	G	G	VG	
	o Vegetation Trend	1:62,500	VP	F	G	G	G	G	G	VG	
	o Type Vigor	1:62,500	VP	F	G	G	G	G	G	VG	
	o Utilization Information										
	- Annual Use	1:125,000	VP	F	G	G	G	G	G	VG	
	- Fire	1:125,000	VP	F	G	G	G	G	G	VG	
	o Percentage of Bare Ground	1:62,500	VP	F	G	G	G	G	G	VG	
	o Percentage of Litter	1:62,500	VP	F	G	G	G	G	G	VG	
	o Disease, Insects, or Parasites	1:62,500	VP	F	G	G	G	G	G	VG	
	o Seeding or Planting Information	1:62,500	VP	F	G	G	G	G	G	VG	

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 4 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
5000	FOREST MANAGEMENT										
5700	FOREST DEVELOPMENT										
	Conduct forest surveys so that the highest and best use of the lands and resources may be realized.										
	Tree Record (Spot Coverage)										
	o Species Description	1:5,000	VG	F	-	-	-	-	VP	P	
	o Disease or Parasites	1:5,000	VG	F	-	-	-	-	VP	P	
	Plot Record (Spot Coverage)										
	o Composition of Plot by Species	1:24,000	G	G	-	-	-	-	P	F	
	o Crown or Canopy Description	1:24,000	G	G	-	-	-	-	P	F	
	o Stand Vigor	1:24,000	G	G	-	-	-	-	P	F	
	o Utilization Information				-	-	-	-	P	F	1,2,7,
	- Timber Sales	1:24,000	G	G	-	-	-	-	P	F	10,11,
	- Fire	1:24,000	G	G	-	-	-	-	P	F	16,17,
	o Percentage of Bare Ground	1:24,000	G	G	-	-	-	-	P	F	18,19,
	o Percentage of Litter	1:24,000	G	G	-	-	-	-	P	F	20,21
	o Disease, Insects or Parasites	1:24,000	G	G	-	-	-	-	P	F	
	o Seeding and Planting Information	1:24,000	G	G	-	-	-	-	P	F	

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 5 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
	Forest Type Record (Area Coverage)										
	o Composition of Type by Species	1:62,500	VP	P	G	G	G	G	G	VG	
	o Vegetative Trend	1:62,500	VP	P	G	G	G	G	G	VG	
	o Crown or Canopy Description	1:62,500	VP	P	G	G	G	G	G	VG	
	o Stand Vigor	1:62,500	VP	P	G	G	G	G	G	VG	
	o Age and Form Class	1:62,500	VP	P	G	G	G	G	G	VG	
	o Utilization Information										
	- Annual Use	1:62,500	VP	P	G	G	G	G	G	VG	
	- Timber Sales	1:62,500	VP	P	G	G	G	G	G	VG	
	- Fire	1:62,500	VP	P	G	G	G	G	G	VG	
	o Percentage of Bare Ground	1:62,500	VP	P	G	G	G	G	G	VG	
	o Percentage of Litter	1:62,500	VP	P	G	G	G	G	G	VG	
	o Disease, Insects, or Parasites	1:62,500	VP	P	G	G	G	G	G	VG	
	o Seeding or Planting Information	1:62,500	VP	P	G	G	G	G	G	VG	
6000	OUTDOOR RECREATION										
6100	OUTDOOR RECREATION INVENTORY										
	Provide a variety of outdoor recreation use opportunities consistent with a quality environment. Preserve and protect significant natural, historic, and cultural resources.										

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 6 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
	Recreation Area (Area Coverage)										
	o Suitability	1:62,500	P	F	G	VG	G	VG	G	VG	
	o Season of Use	1:62,500	P	F	G	VG	G	VG	G	VG	
	o Visitor Use	1:62,500	P	F	G	VG	G	VG	G	VG	
	o Facilities	1:24,000	G	G	F	F	F	F	F	G	
	o Hazards and Undesirable Features Spot Coverage	1:24,000	G	G	F	F	F	F	F	G	
	Historical (Spot Coverage)										
	o Area Type										
	- Lake	1:24,000	G	G	-	-	-	-	P	F	
	- Stream	1:24,000	G	G	-	-	-	-	P	F	
	- Trail	1:24,000	G	G	-	-	-	-	P	F	
	Archeological (Spot Coverage)										1,2,17, 18
	o Type										
	- Shelter	1:5,000	VG	G	-	-	-	-	VP	P	
	- Cave	1:5,000	VG	G	-	-	-	-	VP	P	
	- Pueblo	1:5,000	VG	G	-	-	-	-	VP	P	

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 7 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
	Site (Spot Coverage)										
	o Type										
	- Fort	1:24,000	VG	VG	-	-	-	-	VP	P	
	- Town	1:24,000	VG	VG	-	-	-	-	VP	P	
	- Ranch	1:24,000	VG	VG	-	-	-	-	VP	P	
6610	WILDLIFE INVENTORY										
	Collect Wildlife inventory data to determine their population, trend, consumptive, and non-consumptive uses.										
	Geographic Population Record (Spot and/or Area Coverage)										
	o Potential Habitat Areas	1:24,000/ 1:62,500	G/F	VG/G	-	-	-	-	P/F	F/G	1,22, 23
	o Migration Needs and Patterns	1:24,000/ 1:62,500	G/F	VG/G	-	-	-	-	P/F	F/G	

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 8 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
7000	WATERSHED MANAGEMENT										
7311	GEOLOGY (Area Coverage)										
	Conduct inventories and acquisition of geological data in support of watershed management conservation and development.										
	Geological Formation										
	o Outcrop Locations	1:250,000	VP	VP	F	G	F	VG	G	VG	
	o Physical Characteristics	1:250,000	VP	VP	F	G	F	VG	G	VG	
	Geomorphology (Land Forms)										
	o Topographic Expression	1:125,000	VP	P	F	G	F	VG	G	VG	
	o Drainage Classification	1:125,000	VP	P	F	G	F	VG	G	VG	1,5,21,
	o Land Use Classification	1:125,000	VP	P	G	G	G	VG	G	VG	24,25, 26,27,
	Geological Hazards										28,29, 30,31,
	o Earthquake Potential (DCP)	1:250,000	VP	VP	G	G	G	G	G	VG	32,33,
	o Volcanic Activity (DCP)	1:250,000	VP	VP	G	G	G	G	G	VG	34
	o Landslide Potential	1:250,000	VP	VP	G	G	G	G	G	VG	

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 9 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
	Structual Geology										
	o Joints and Fault Systems										
	- Orientation	1:250,000	VP	VP	F	G	F	G	G	VG	
	- Density	1:250,000	VP	VP	F	G	F	G	G	VG	
7312	SOILS										
	Conduct soil inventories on public lands to provide basic soil information and interpretation that will assist in planning and development of multiple resource management decisions.										
	Mapping of Soil Associations (Area Coverage)										1,2,12, 13,16,
	o Soil Association	1:62,500	VP	G	G	G	G	G	G	VG	17,18,
	o Acres	1:62,500	VP	G	G	G	G	G	G	VG	19,35
	o Permeability	1:62,500	VP	G	G	G	G	G	G	VG	
	o Available Water Holding Capacity	1:62,500	VP	G	G	G	G	G	G	VG	

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 10 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	(4) Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	(5) 1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
7313	VEGETATIVE COVER Determine cover inventory to interpret hydrologic characteristics of various watershed covers for use in general watershed planning, and for design of hydraulic structures. Low Intensity Cover Inventory (Area Coverage) Low intensity of cover data is required for storm run-off analysis. High Intensity Cover Inventory (Area Coverage) High intensity of cover data is used when storm run-off estimates are required for design of hydraulic structures. Note: Additional vegetative cover information is available in Procedure #4000 RANGE MANAGEMENT.	1:62,500 1:24,000	VP VP	G G	G G	G G	G G	G G	G G	VG VG	1,2,7, 8,9,10, 11,14, 15,16, 17,18, 19
7315	SURFACE WATER HYDROLOGY Facilitate the planning and design of simple structures and the treatment measures involving overland water flow.										

Table 7. Suitability of Remote Sensing Technology as Applied to "BLM" Functions (Sheet 11 of 11)

(1) BLM Procedure #	(2) BLM Functions	(3) Minimum Acceptable Photography/ Imagery Scale Required	(4) Suitability for Acquisition & Processing Color IR Photography from Aircraft Flights of: Low Level 35mm	Medium Level 9"x9" Format	(5) Acquisition & Processing of Imagery from Satellites 1975 - 1978 LANDSAT 1 & LANDSAT 2 Suitability of: MSS Spectral Bands 4	5	6	7	Color Composites and/or Computer Classifications	1979 ERTS-C & EOS Suitability of: Color Composites and/or Computer Classifications	References
	Surface Water (Area Coverage)										
	o Streamflow (IBM Streamflow Model can be utilized)	1:62,500	P	F	G	G	G	VG	G	VG	1,21,36, 37,38, 39,40, 41,42
	o Stream Sedimentation	1:24,000	P	G	G	G	G	VG	G	VG	
	o Streamflow Pattern	1:62,500	P	G	G	G	G	VG	G	VG	
	o Flood Area	1:62,500	P	G	G	G	G	VG	G	VG	
	o Flood Forecast (IBM Flood Forecast Model can be utilized)	1:62,500	P	F	G	G	G	VG	G	VG	
9110	TRANSPORTATION SYSTEMS										
	Inventory of Ground Transportation										
	o Roads (Area Coverage)	1:62,500	P	F	G	VG	G	VG	G	VG	1,43
	o Bridges (Spot Coverage)	1:24,000	VG	G	G	VG	G	VG	G	VG	
	o Trails (Area Coverage)	1:24,000	F	G	F	F	F	F	F	G	
	Inventory of Air Facilities (Spot Coverage)										
	o Airports	1:24,000	VG	VG	G	VG	G	VG	G	VG	
	o Heliports	1:24,000	VG	VG	-	-	-	-	P	F	
	o Landing Fields	1:24,000	VG	VG	-	-	-	-	P	G	

1 Usefulness of ERTS-1 Satellite Imagery as a Data-Gathering Tool by Resource Managers in the Bureau of Land Management, R. Gordon Bentley

2 Change in Land Use in the Phoenix (1:250,000) Quadrangle, Arizona Between 1970 and 1973: ERTS as an Aid in a Nationwide Program for Mapping and General Land Use, John L. Place

3 Mineral Exploration with ERTS Imagery, Stephen M. Nicolais

4 An Evaluation of the Suitability of ERTS Data for the Purposes of Petroleum Exploration, Robert J. Collins, F. P. McCown, L. P. Stonis, Gerald Petzel, and John R. Everett

5 Relationship of Roof Falls in Underground Coal Mines to Fractures Mapped on ERTS-1 Imagery, Charles E. Wier, Frank J. Wobber, Orville R. Russell, Roger V. Amato, and Thomas V. Leshendok

6 Automated Strip-Mine and Reclamation Mapping from ERTS, Robert H. Rogers, Larry E. Reed, and Wayne A. Pettyjohn

7 The Utility of ERTS-1 Data for Applications in Agriculture and Forestry, R. Bryan Erb

8 Crop Identification and Acreage Measurement Utilizing ERTS Imagery, William H. Wigton and Donald H. Von Steen

9 Vegetation Density as Deduced from ERTS-1 MSS Response, C. L. Wiegand, H. W. Gausman, J. A. Cuellar, A. H. Gerbermann, and A. J. Richardson

10 Forest and Land Inventory using ERTS Imagery and Aerial Photography in the Boreal Forest Region of Alberta, Canada, C. L. Kirby

11 Application of ERTS-1 Imagery to Land Use, Forest Density and Soil Investigations in Greece, N. J. Yassoglou, E. Skordalakis, and A. Koutalos

12 Mapping Soils, Crops, and Rangelands by Machine Analysis of Multi-Temporal ERTS-1 Data, Marion F. Baumgardner, James A. Henderson, Jr., and LARS Staff

13 Application of ERTS-1 Imagery in Mapping and Managing Soil and Range Resources in the Sand Hills Region of Nebraska, Paul M. Seevers, David T. Lewis, and James V. Drew

14 Vegetation Mapping from ERTS Imagery of the Okavango Delta, Douglas T. Williamson

15 Monitoring Vegetation Systems in the Great Plains with ERTS, J. W. Rouse, Jr., R. H. Haas, J. A. Schell, and D. W. Deering

16 The Application of ERTS-1 Data to the Land Use Planning Process, James L. Clapp, Ralph W. Kiefer, Edward L. Kuhlmey, and Bernard J. Niemann, Jr.

17 Application of ERTS-1 Satellite Imagery for Land Use Mapping and Resource Inventories in the Central Coastal Region of California, John E. Estes, Randolph R. Thaman, and Leslie W. Senger

18 Evaluation of ERTS-1 Imagery for Land Use/Resource Inventory Information, Ernest E. Hardy, James E. Skaley and Elmer S. Phillips

19 Photointerpretation of ERTS-A Multispectral Images Analysis of Vegetation and Land Use for the Valencia Lake Basin Region, F. Salas, M. Pineda, and A. Arismendi

20 SO_2 Damage to Forests Recorded by ERTS-1, Peter A. Murtha

21 Techniques for Computer-Aided Analysis of ERTS-1 Data, Useful in Geologic, Forest and Water Resources Surveys, Roger M. Hoffer and Staff

22 An Evaluation of the Use of ERTS-1 Satellite Imagery for Grizzly Bear Habitat Analysis, Joel R. Varney, John J. Craighead, and Jay S. Sumner

23 Utility of ERTS for Monitoring the Breeding Habitat of Migratory Waterfowl, Edgar A. Work, Jr., David S. Gilmer, and A. T. Klett

24 Summary of an Integrated ERTS-1 Project and its Results at the Missouri Geological Survey, James A. Martin, William H. Allen, David L. Rath, and Ardel Rueff

25 A New Method for Monitoring Global Volcanic Activity, Peter L. Ward, Elliot T. Endo, David H. Harlow, Rex Allen, and Jerry P. Eaton

26 Evaluation of ERTS Imagery for Spectral Geological Mapping in Diverse Terranes of New York State, Y. W. Isachsen, R. H. Fakundiny, and S. W. Forster

27 Geologic Applications of ERTS Images on the Colorado Plateau, Arizona, Alexander F. H. Goetz, Fred C. Billingsley, Donald P. Elston, Ivo Lucchitta, and Eugene M. Shoemaker

28 ERTS-1, Earthquakes, and Tectonic Evolution in Alaska, Larry Gedney and James VanWormer

29 Structural Geology of the African Rift System: Summary of New Data from ERTS-1 Imagery, P. A. Mohr

30 A Study of the Temporal Changes Recorded by ERTS and Their Geological Significance, Harold D. Moore and Alan F. Gregory

31 Geologic Evaluation and Applications of ERTS-1 Imagery Over Georgia, S. M. Pickering and R. C. Jones

32 Geological Photointerpretation of the Paraguana Pennisula Using ERTS-A Multispectral Photography, Carlos Albrizzio

33 Geologic Interpretation of ERTS-1 Satellite Images for West Aswan Area, Egypt, E. M. El Shazly, M. A. Abdel-Hady, M. A. El Ghawaby and I. A. El Kassas

34 Geologic Hypotheses on Land Tanganyika Region, Zaire, Drawn from ERTS Imagery, Ulyera Wolyce and Sendwe Ilunga

35 ERTS-1 MSS Imagery: Its Use in Delineating Soil Associations and as a Base Map for Publishing Soils Information, Frederick C. Westin

36 ERTS-1 Data In Support of the National Program of Inspection of Dams, G. E. Graybeal, F. G. Jall, B. H. Moore, and E. H. Schlosser

37 Water-Management Models in Florida from ERTS-1 Data, Aaron L. Higer, Alfred E. Coker, and Edwin H. Cordes

38 Measuring Watershed Runoff Capability with ERTS Data, Bruce J. Blanchard

39 ERTS-1 Flood Hazard Studies in the Mississippi River Basin, Albert Rango and Arthur T. Anderson

40 Optical Data Processing and Projected Applications of the ERTS-1 Imagery Covering the 1973 Mississippi River Valley Floods, Morris Deutsch and F. H. Ruggles

41 Hydrologic Applications of ERTS-1 Data Collection System in Central Arizona, Herbert H. Schumann

42 Aircraft and Satellite Monitoring of Water Quality in Lake Superior near Duluth, James P. Scherz, Michael Sydor, and John F. Van Domelen

43 Application of ERTS Imagery in Estimating the Environmental Impact of a Freeway Through the Knysna Area of South Africa, Douglas T. Williamson and Brian Gilbertson

The rating of Range Management clearly indicates that the acquisition of data to analyze Plant Records and Plot/Transact Records will remain in the domain of airborne remote sensing operations with extensive ground truth information. Therefore, it is ranked very good, and good in column 4 of Table 7.

In Range Management the satellite data becomes useful when the minimum area coverage is well within the spatial resolution of the satellite (ERTS-1 is approximately 1 acre), such as the analysis of Vegetative Type Record which may cover large areas too expensive to be flown by aircraft for the total area under consideration. In such cases, satellite data in conjunction with medium level aircraft color IR photography and proper ground truth information can provide excellent results in terms of accuracy and efficiency. Therefore, the ranking of satellite data for Vegetative Type Record is good.

According to the objectives in Table 6 of Earth Observation Satellite, (EOS) to be launched by 1979, the spatial resolution of EOS is considered to be eight times better than ERTS-1 spatial resolution. Therefore, EOS total suitability to Range Management (for Vegetative Types Record) is very good.

The rating of MSS Spectral Bands of ERTS-1 within column 5 of Table 7 is based on results given by many ERTS-1 investigators. When the total suitability of ERTS-1 rating is considered to be very poor--mainly due to its poor resolution for a given function such as Plant Record of the Range Management--the rating of all the MSS Spectral Bands are considered to be useless, and therefore <u>not rated</u> (-).

In Minerals Management where a comprehensive inventory of mineral resources requires the coverage of large areas of BLM, cost of aircraft flights can be formidable to fulfill the needed requirements. However, ERTS-1 satellite resolution capabilities, repetitive coverage, and its synoptic view have allowed the acquisition of several statewide mineral inventories not previously completed (and that could not be completed in any other way). This capability provided a good ranking for the satellite suitability of Minerals Resource Inventory.

It is important to point out that the subjective ratings applied for the suitability of aircraft photography and satellite imagery in Table 7 is solely the judgment of the working group based upon approximate cost judgments for the acquisition and processing of photography or imagery for a total area of a given function, the combination of resolution involved.

The last column contains references, which are listed after Table 7, from the Third Earth Resources Technology Satellite-1 Symposium.

In summary, we recommend the proper use of latest remote sensing techniques of LANDSAT 1, and LANDSAT 2, where applicable, together with conventional aerial photography (where several BLM planning units have considerable experience in the acquisition and application of color IR photography) supported by surveys based on ground observation functioning in concert, to provide a timely and accurate inventory of the current and future use of the BLM land resources.

TASK 1AB-7/8: Survey of Image Processing Technology and Systems

Since the mid-sixties image data processing systems have progressed from relatively simple interpretation aids of a few pioneers to large and complex computer analysis systems located throughout the country. Major, significant advances have been made in this field however, much work remains. Despite the fact that many feel that the state-of-the-art of image processing and analysis is still primative, results are being obtained and used in decision making and planning of our countries natural resources. These techniques and systems, though still in an R&D phase could be used by the BLM in its land management activities. As improvements are made and remote sensing systems are perfected for operational production use, they have the potential for providing timely and cost effective data for use in the BLM's planning and management effort.

This survey has been limited to image analysis systems operating on general purpose computers. Equipment is available which falls outside this scope which may be of interest. For example, color additive viewers are mechanical devices which project multispectral transpancies through filters onto a viewing screen. By manipulating spectral channels and filters, analysts have had success in enhancing certain features. These devices are typically used as aids to photo-interpretation.

However, since the BLM's land management responsibilities and activities are so varied and interrelated it is assummed that systems capable of a wide variety of analytical functions would be more applicable. The systems described in this section have such multifunction or multi-application capability. All can be considered to be R&D tools. As such, they require human interpretation and intervention at points between processing steps. The state-of-the-art has not yet advanced to the point where images are fed into one end of a box and "answers" automatically come out the other end. However, operational/production systems may not be far away. NASA JSC is currently modifying the ERIPS system for production work on a large scale copy inventory project.

The systems described in the following tables are representative of systems in use today. All are part of continuing efforts and are constantly being updated and improved. It must be noted that this survey was not intended to be exhaustive but representative in nature.

System Name	RECOG
Developed by	Colorado State University, Fort Collins, Colo.
Funded by	National Science Foundation
Operational Date	1971
Computer Used	CDC 6400/Scope/90% FORTRAN, 10% COMPASS
Terminal Used	(BATCH)
Operating System	Scope
Programming Languages	FORTRAN (90%), COMPASS (10%)
Inputs	RECOG accepts CCT data input from a variety of sources and converts them to a special format.
Outputs/Products	Various statistical and classification summary reports, scatterograms, and histograms are generated. These reports aid in the selection of training fields and the evaluation of various classifiers on test fields as well as summarizing final classification results. Spectral density and classification maps are generated on line printer and microfile peripherals.
System Description/	RECOG development was based upon the Purdue University LARS system. Though the programs were redesigned and rewritten when conversion was made from the IBM 360 to the CDC 6400 the functional capabilities and algorithms were essentially unchanged. The major capability that was added to the system after its initial development is spatial analysis in the form of the two-dimensional Fourier Analysis. RECOG was designed for instructional and research needs rather than production processing.

System Name	KANDIDATS (Kansas Digital Image Data System)
Developed by	University of Kansas
Funded by	NASA and Internal Funds
Operational Date	July, 1974
Computer Used	PDP-15
Terminal Used	Super B
Programming Languages	FORTRAN (90%), AL (10%)
Inputs	KANDIDATS accepts CCT data input from a variety of sources and converts them to a common format.
Outputs/Products	Data display capability with scatterograms and histograms, grey-tone image display with overprinting, and digital image color map display.
System Description	The multi-image processing programs allow for image editing, registering, congruencing, quantizing, clustering, feature extraction, image size and/or dimensionality reduction, image texture analysis, and image pattern recognition. The pattern discrimination programs use a variety of decision rule types including a distribution free Boyes rule which can only be used on coarsely quantized data, a Boyes decision rule assuming the category conditional probabilities are of some given type of multivariate distribution, a linear decision rule, and a nearest neighbor decision rule. Irregular shaped fields may be specified for statistics computations. Spatial, interactive, and chaining clustering programs are available.

System Name	LARSYS
Developed by	Laboratory for Applications of Remote Sensing (LARS), Purdue University
Funded by	NASA/USDA
Operational Date	1967
Computer Used	IBM System/360 Model 67
Terminal Used	IBM 2741/2780, Hazeltine 2000, Datapoint 3300, Special gray scale terminal
Operating System	CP/67 - CMS
Programming Languages	FORTRAN (90%), Assembler Language (10%)
Inputs	LARSYS - II formatted image tapes. Control cards may be entered on card readers or remote terminals.
Outputs/Products	Over twenty individual reports may be requested. Images are output as line printer (or terminal) shade prints.
System Description	LARSYS has been continually upgraded and improved upon since 1967. Originally a batch system, it now operates interactively in a time sharing environment supporting several users simultaneously. Remote terminals are typewriter type devices, a special gray scale CRT terminal is available in the LARS facility. LARSYS contains programs for statistics computation and analysis, separability computation, per point, per field, and clustering classifiers, and a large array of reports including histograms, statistics, maps, performance results, and separability listings. LARSYS also can write tapes and punch cards containing results and variables. LARSYS is well documented and very easy to learn and use. In January, 1975, it will be available on the GSA INFONET system.

System Name	Earth Resources Interactive Processing System (ERIPS).
Developed by	NASA/IBM
Funded by	NASA JSC
Operational Date	1972
Computer Used	IBM System/360 Model 75
Terminal Used	Specially designed Digital Television Equipment
Operating System	RTOS
Programming Languages	Assembler Language (50%), PL/I (45%), FORTRAN (5%)
Inputs	ERTS CCTS, LARSYS II formated tapes, universal form tapes. User controls system by making selections or entries or CRT menus.
Outputs/Products	Images and reports on terminal CRTs, CCTs, images on microfiche, hardcopy.
System Description	ERIPS is a fully interactive remotely sensed data analysis system. The system is modular and contains application programs for registering images, classifying and clustering image data, change detection, error analysis, loading and displaying images, and for producing a variety of reports. Primarily a research analysis tool, NASA is currently modifying the system for large scale production work. Part of that modification is the addition of a high speed attached processor for added speed and a data base management subsystem.

System Name	Algorithm Simulation Test and Evaluation Program (ASTEP)
Developed by	NASA/TRW
Funded by	NASA JSC
Operational Date	1972
Computer Used	UNIVAC 1110
Terminal Used	T. I. Silent 700, Datapoint 3300
Operating System	Exec 8
Programming Languages	FORTRAN (98%), Assembler Language (2%)
Inputs	Image data in LARSYS II, ERTS, or Universal format tapes. Control card entered via card reader or terminal.
Outputs/Products	Classification Maps (line printer, CCTS, various system reports.
System Description	ASTEP is a modular computer program used primarily for the purpose of testing and evaluation of methods of processing earth resources data. The program operates in either a batch or interactive mode and currently contains over 100 subroutines. These include data classification and display algorithms, statistical analysis and utility support routines and feature selection capability. Because of the modular configuration of ASTEP, new data processing algorithms can be added with minimal impact to the program. This structure makes it an excellent tool for both testing existing techniques and for developing new algorithms.

System Name	Image 100
Developed by	General Electric
Funded by	General Electric
Operational Date	1972
Computer Used	DEC PDP-11 and Image 100 analyzer
Terminal Used	Image 100 consol
Operating System	
Programming Languages	
Inputs	Color/color IR photos, Multiband B/W photos, digital tapes.
Outputs/Products	Color CRT display, terminal hardcopy, contour plots, line printer maps, reports, image tapes.
System Description	The Image 100 is an interactive system composed of general and special purpose hardware and software. System capabilities include signature analysis, classification (Thresholding and clustering), registration, radiometric and geometric correction, rationing and normalization, various transformation algorithms, and edge enhancements. Many functions are hardware implemented giving extremely rapid response.

System Name	Video Image Communications and Retrieval (VICAR)
Developed by	JPL/Cal Tech
Funded by	NASA
Operational Date	1967
Computer Used	IBM System/360 Model 44
Terminal Used	Special Consol
Operating System	44 PS
Programming Languages	FORTRAN (60%), Assembler Langungi (40%)
Inputs	VICAR format image tapes, ERTS CCTS. Card or consol inputs
Outputs/Products	Image tapes, reports and plots, Image hardcopy
System Description	VICAR is a large image processing system containing over 200 programs of which over half are of general interest. The remainder were written around peculiarities of various projects such as the mariner spacecraft camera. The system contains routines for image mosaicing, correlation and registration, classification, frequency filtering, averaging ratioing, historgramming, contrast stretching, change detection, boundary enhancement, geometric and radiometric correction. VICAR is part of JPL'S Image Processing Laboratory which contains a large array of sophisticated hardware such as film digitizers, color recorders, X Y digitizers, etc.

1. IMAGE PROCESSING DEVELOPMENT RECOMMENDATIONS

The primary objective for development of an image processing capability within the Bureau of Land Management is to increase the efficiency of Bureau personnel in interpreting aerial photographs and space imagery earth resources data collected over administered lands. The proposed approach consists of utilizing an existing image processing subsystem as a stepping-stone in developing the final operational subsystem required by the Bureau. This interim subsystem would be used to define the processes and procedures for performing computer assisted photo-interpretation and would become the basis for the final operational image processing subsystem. The interim subsystem would also be used in developing BLM Manual Procedures for acquiring and processing remote sensed data as well as the required supporting ground truth data.

Recommendations will be made on: (1) Interim Subsystem Selection - the selection of a base line image processing capability; (2) Interpretation Technique Selection - selection of image processing techniques which will result in BLM standards for computer aided photo-image interpretation; (3) Final Subsystem Development - development of efficiency modifications to the base line capability which will result in a production-oriented image processing subsystem; and (4) Final Subsystem Implementation - down-stream implementation of this production oriented sub-system into BLM's integrated management information system.

1.1 Interim Subsystem Selection

Selection of a previously developed (baseline) and currently operational image processing subsystem is recommended. The alternative option, that of design and development, from scratch, of such a capability, is not recommended due to the extremely high development costs involved.

The subsystem selected by Bureau management must meet two extremely important criteria.

First, the subsystem should be available to BLM and developed to a point where a baseline version has been established. A baseline version is defined to be a package of computer programs that have been written, bench mark tested, fully documented and executed as an operational subsystem.

The other criteria to be met is that of suitability. BLM is required to interpret earth resources for inventory data on lands which it administers. This interpretation is required for planning, recommending, authorizing and managing multiple-use areas; development of environmental impact statements associated with a variety of multiple land use proposals and decisions; and evaluation of compliance, unauthorized use, natural disaster and other factors affecting earth resources.

Therefore, the selection of an image processing capability must be based on its suitability to perform those BLM tasks for which it was intended. In this case proven interpretation technique capabilities are required of which a sub-set can be selected for the final subsystem. Also required is an image processing capability developed to a level requiring the least modification to bring it to its final production-oriented form for use within BLM.

1.1.1 Determining Availability

Availability of an existing image processing subsystem for use as an interim BLM subsystem can be determined by combining factors relating to ownership, level of development and implementation considerations.

The most cost effective combination would be a subsystem which: (a) has been developed for, and is owned by, a government agency; (b) does currently exist in baseline version form and; (c) is currently implemented on a computer configuration which would be very compatible with the Bureau's future computer configuration.

1.1.2 Determining Suitability

An existing image processing subsystem, for use as an interim BLM subsystem, must have the following characteristics:

(a) An interactive (man with machine) mode of operation whereby the operator can control the interpretative process at various points. This feature will allow rapid progress in selecting image interpretation processing procedures which best suit BLM's needs for photo-image interpretation and which would be incorporated into the final production-oriented subsystem.

(b) An automatic mode of operation whereby the scene classification (type-mapping) process is not supervised by the operator. This unsupervised technique would be evaluated to determine to what extent this autoprocessing feature would be utilized in the final subsystem.

A very desirable aspect to look for in selecting an interim image processing capability is its planned future development. A candidate subsystem whose development is controlled, e.g., software quality-control and configuration-management are applied and whose future development is planned/scheduled, would allow any new version release to become available to BLM in the future.

The Bureau could, at that time, evaluate its need for such an added capability and decide whether or not to implement the features of the new version. With the advent of new aerial cameras as well as satellite programs this consideration could be extremely beneficial to BLM.

1.2 Interpretation Technique Selection

Primary emphasis will be placed on selecting interpretation technique capabilities of the candidate interim subsystem for use in the final subsystem rather than on development of new image processing techniques. Therefore, the interim subsystem to be selected by the Bureau should have the following image processing technique capabilities:

(a) radiometric correction of sensor non-linearity and other internal distortion, etc.

(b) geometric correction of camera angles, curvature of the earth, etc., through use of natural or cultural control points such as highway intersections, dams, lakes, etc.

(c) image subtraction to show trend

(d) image manipulation to control positioning of scene data for display

(e) image scene classification to perform photo-image interpretation both interactive mode, to manually direct image processing at various points; and auto mode, to perform automatic classification of an entire scene or portions thereof.

Once the interim image processing subsystem has been selected and installed this subsystem will then be used to select optimum procedures to be used in the final subsystem for interpreting Bureau specified aerial photographs or satellite imagery data. By having control over each step of the image processing chain while in the interactive mode, the development analyst would optimize the procedures for loading and registering image data; performing scene classification and annotation; generating resource type-maps; and other image manipulation and interpretive processes. When fully developed, these procedures would become easy to understand and follow and intended for usage by non-programmer Bureau specialists in range, wildlife, watershed, cartography, etc.

1.3 Final Subsystem Development

Since the image interpretation and manipulation technique capabilities are assumed to already exist in the interim subsystem selected, the analysis processing software modules providing these capabilities need only be optimized for the final production-oriented subsystem. The requirements for input processing of digital images from computer compatible tape (CCT) and from aerial photograph transparencies will be determined and the necessary software modules will be developed for the final image processing subsystem.

It is recommended that the primary output product (vegetative, water, land-use, etc., type-map) be in digital form and compatible with the data base containing those developed by manual photo interpretation.

Other output products such as first generation image/photographic prints, transparencies, type-maps plotted on paper or mylar and other products would be determined by BLM and would be developed.

1.4 Final Subsystem Implementation

It is recommended that the final image processing subsystem be located at the Bureau's Denver Service Center central computer facility to service image processing requirements from all district, state and headquarter offices.

2. BLM MANUAL PROCEDURE DEVELOPMENT

The Image Processing Development section describes how the interim image processing subsystem, itself, would be used to select automated interpretation techniques and be modified or developed into a final sybsystem. This section will describe how the interim subsystem would be used in developing BLM Manual procedures associated with image processing of remote sensed data.

It is recommended that the interim subsystem be used by the Bureau's Standards and Technology staff, Remote Sensing staff, Scientific Development staff and other BLM personnel to:

(a) select and specify standards for aerial photography and space imagery to be used by BLM and which will be processed by the image processing subsystem. The interim subsystem would be used to evaluate the effectiveness and extent to which computer aided interpretation can be performed on data collected by single spectral band vs. multi-band aerial cameras; different flight altitudes, etc., to assist these staffs in specifying standards.

(b) Select and specify standard BLM image-processing products such as resource type-maps, enhanced image prints and transparencies, etc., to be used by district, state and other Bureau office staffs. The interim subsystem would be used to evaluate the impacts in both additional software development and quality of products that would be output by the image processing subsystem.

(c) Development of techniques in collecting support ground truth data. The interim subsystem would be used to develop procedures for collecting and entering into the image processing subsystem training-field ground truth data associated with the scene to be interpreted. Procedures would also be developed which would optimize the collection of post-interpretation ground truth data. Development of an information bank of natural resource spectral signatures would also be obtained through use of the interim subsystem.

3. IMAGE PROCESSING USER GUIDE DEVELOPMENT

The basic task of the image processing subsystem is to assist Bureau personnel in the interpretation of aerial photographs or space imagery. During an image processing session the Bureau specialist would load and possibly register his desired scene image and proceed through processing steps of scene classification. The final results being one or more type-maps developed by the subsystem. The scene data he would be interpreting would be familiar to him since it would be that of a planning unit within his district or some other area administered by BLM. The computer subsystem would be user-oriented and provide him with messages, reports, etc., to guide him through processing steps. The use of an image processing user's guide would be required to plan for and conduct such an image processing session. It is recommended that a team made up of ADP, Remote Sensing and Scientific Development staff, be formed to develop an Image Processing User's Guide. The guide should describe in layman's terms the capabilities of the image processing subsystem as well as step by step procedures for utilizing the subsystem. The guide would be updated upon implementation of new or refined techniques or additional software features or hardware equipment.

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